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To Binder :—Insert to face page 142.]

CORRIGENDA.

Page 142, line 10, *for* "too intimate connection," *read* "combined use."
" 143, " 20, *omit* "if."
" " " 25, *omit* "so."
" " " 31, *for* "Boguslaus," *read* "Bogislaus."
" 145, " 9, *for* "effective," *read* "efficient."
" " " 4 (of the note), *for* "when," *read* "that is to say."
" 147, " 6 (from bottom of the note), *for* "extremities," *read* "extremity."
" 154, " 8, *for* "casual," *read* "causal."
" 155, " 29, *for* "furrowed cells," *read* "cleavage-cells."
" 158, " 2, *for* "in," *read* "upon."
" 159, " 29, *for* "grooving," *read* "cleavage."
" 161, " 30, *for* "indistinguishable," *read* "not an independent one."
" 163, " 8, *for* "as an organ of departure for the skin," *read* "having as an organ of departure—the skin."
" " " 10, *for* "as an organ of departure for the intestine," *read* "having as an organ of departure—the intestine."
" 164, " 30, *for* "latter, just," *read* "latter. Just."
" 165, " 4, *for* "during the grooving," *read* "during cleavage."
" " " 4, *for* "furrowed cells," *read* "segmentation-products."
" " " 5, *for* "germinal vesicle," *read* "blastodermic sac."
" " " 15, *for* "before it developed the true body cavity," *read* "before the true body cavity developed."

To Binder :—Insert to face page 223.]

CORRIGENDA.

Page 227, line 4, *omit* "the."
" 228, " 12, *omit* "much more."
" 230, " 19, *for* "germ-lamellæ," *read* "germ-lamella."
" 236, " 18, *for* "is of different epochs and of phylogenetic origin," *read* "is phylogenetically of different epochs and origin."
" 238, " 3 (from bottom), *for* "furrowed cells," *read* "cleavage-masses."
" 239 " 32, *for* "constitutive," *read* "constituent."
" 240 " 8, *for* "improvement," *read* "development."
" " " 19, *for* "very," *read* "every."

MEMOIRS.

Some Account *of* Kleinenberg's Researches *on the* Anatomy *and* Development *of* Hydra. By Professor Allman, M.D., LL.D., F.R.C.S.I., F.R.S., M.R.I.A.

Since Abraham Trembley about a hundred and thirty years ago first made us acquainted with some of the most important facts in the morphology and vital phenomena of Hydra, this remarkable little animal, which, along with Cordylophora, constitutes all we as yet know of the hydroid fauna of the fresh waters of our globe, had become the subject of various investigations. Many of these, however, had led to results manifestly erroneous, while even the most careful and complete of them had left much to be still determined regarding the anatomy, development, and life-history of an animal whose examination by Trembley marked out one of the great epochs in the progress of biological research.

Quite lately, however, a memoir on Hydra[1] has been published by a German zoologist, Dr. Nicolaus Kleinenberg, which, in exhaustiveness and in the value of the results arrived at, must take its stand among the most important of recent contributions to the zoology of the lower members of the animal kingdom. It is proposed to give here a *résumé* of the most significant facts which the researches of Kleinenberg have made known to us—researches which extend over the fields of both anatomy and development. His observations have been made chiefly on *Hydra viridis,* but they also include the forms which he mentions under the names of *H. aurantiaca* and *H. grisea,* and which are probably only varieties of *H. vulgaris.*

The anatomical section of the memoir embraces the structure of both endoderm and ectoderm—tissues which differ in some very important points from one another.

The endoderm is composed entirely of cells, which are arranged in a single layer. These cells are simple nucleated

[1] 'Hydra, eine Anatomisch-entwicklungsgeschichtliche Untersuchung.' Von Dr. Nicolaus Kleinenberg. Mit vier lithographirten Tafeln. Leipzig, 1872.

masses of protoplasm, quite destitute of investing membrane. In the tentacles and basal portion of the animal each encloses a vacuole, which is filled with a clear fluid, which, in its behaviour with reagents, scarcely differs from pure water. In the cells of the stomach-region there is no constant vacuole, these cells being here usually in the condition of solid protoplasm masses.

Imbedded in the protoplasm of the endodermal cells of *H. viridis* there occur not only the nucleus, but the green granules. These have a diameter of 0·009 mm. They consist, fundamentally, of a firm mass, very rich in albumen, coloured dark brown by iodine and deep red by carmine or aniline. Lying over this is an exceedingly thin layer of green colouring matter, which, in its optical and chemical properties, is intimately allied to the chlorophyll of the vegetable cell, if it be not absolutely identical with it. It will be here seen that the conclusions of Kleinenberg correspond with those of Cohn, who had already maintained, as the result of careful investigation, the identity of the green matter of Hydra, and of certain green infusoria with the chlorophyll of plants.

With the green granules are also associated smaller corpuscles which have an angular shape, and instead of the pure green of the others, possess a dark sooty colour. These are frequently found conglomerated into heaps of very small, dark brown or black granules. The free end of the cell never contains chlorophylle granules; here, on the contrary, the brown and black granules are accumulated.

In *Hydra aurantiaca* and *H. grisea* the place of the chlorophyll spherules is taken by colourless, round or oval, firm albuminous corpuscles, which are developed in the cells forming the endoderm of the stomach cavity. Apart from the want of chlorophyll, these are quite like the green corpuscles of *H. viridis*. They are also associated, as in the latter species, with dark granules. In all the species fatty particles and oil-drops are also found imbedded in the endodermal protoplasm.

In all parts of the body cavity certain cells of the endoderm may be seen carrying a long very slender cilium; rarely two such cilia may be found on one cell. The ciliated cells, however, are isolated, and do not constitute a continuous ciliated lining of the body cavity, and Kleinenberg calls attention to the interesting analogy between this and an entirely similar form of vibratile tissue (the Geisselzellen of Haeckel) which occurs in the sponges.

Such are the most important points of structure which we

may now regard as established in the endoderm of Hydra. Most of them, it is true, have already been made known by other observers, but it is, nevertheless, a matter of no little value that they should be thus confirmed by the very careful researches of Kleinenberg.

While the endoderm thus forms a simple cell layer, the ectoderm on the other hand is a complex membrane. It is in Kleinenberg's statements regarding the structure of this part of the Hydra body that the most original results of his anatomical investigations are to be found. The methods which he has employed with most success in his examination of the ectoderm consist in making transverse sections of the animal after it has been hardened by being allowed to remain during a period varying from one to three days in a solution of chromic acid of 0·025 per cent., and then steeping these sections for a quarter or half an hour in dilute acetic acid 0·25—0·05 per cent. The preparations may then be coloured with fuchsin and preserved in dilute glycerine.

In sections thus made we find externally a simple layer of large cells, which are in the condition of solid protoplasm masses, with large ellipsoidal nuclei. These cells touch one another only by their broad bases, which are turned towards the surface of the body; while lying below and running up between them there is a multitude of smaller cells, some of which contain a thread-cell, some only a well-marked nucleus; finally, lying beneath these, and in close contact with the endoderm, is a narrow clear zone in which the well-known fine muscular fibrillæ are imbedded.

The very important statement is now made that each of the large cells which form the most superficial part of the ectoderm, tapers away towards the centre of the section and either terminates in a single process or becomes cleft dichotomously, so that the inner end of the cell appears many-times branched. The cell-processes thus formed all run towards the endoderm; when they meet this the finest of them bend sharply at a right angle, and thus form the simple layer of longitudinal soft fibrillæ which lies in contact with the endoderm.

To these fibrillæ he assigns the name of muscle-processes (Muskelfortsätze). They are all bound together by an abundant intervening substance into a continuous lamina, which is everywhere included between the endoderm and the ectoderm. The substance by which the fibrillæ are bound together not only fills the spaces between the fibrillæ, but, increasing in volume towards the endoderm, forms a continuous thin membrane, which by maceration and tearing

may sometimes be detached from the muscle processes. It is during life very soft, clear and colourless, and destitute of granules. It is not coloured by iodine or carmine, but under the action of gold chloride it acquires a straw colour. It is to the membrane thus formed by the muscular fibrillæ and their connective medium that Reichert has given the name of "Stützlamelle."

From the peculiar form of the large endodermal cells there necessarily lies between their outer ends, where they are in close contact with one another, and the muscular lamina, which lies in contact with the endoderm, a system of intercommunicating lacunæ. These lacunæ are filled by the smaller cells already mentioned. The tissue thus formed by the small cells he names the interstitial tissue of the ectoderm; it necessarily forms a network and not a continuous layer. The cells composing it are fusiform or flattened, and their protoplasm surrounds a relatively large nucleus which often forms the chief mass of the cell.

It is in the cells of this interstitial tissue that the thread-cells are formed. These bodies are described as commencing in the form of a spherical clear space which shows itself by the side of the nucleus, and which, without being sharply circumscribed at first, gradually acquires a double contour, and assumes the definitive form of the thread-cell within which the spirally wound filament is developed. It would seem that some time after the completion of the thread-cell the nucleus of the generating cell regularly disappears. This cell then loses its granular contents and surrounds the thread-cell as a spherical or oval covering. The thread-cells are now pushed forward from the deeper parts where they originate towards the surface, where they lie between the large cells or become even imbedded in their protoplasm. Kleinenberg is unable to add any fact to what is already known regarding the structure of the mature thread-cell.

The structure of the foot differs from that of the rest of the body in the fact that the interstitial tissue, and consequently the thread-cells which originate in this tissue, are entirely absent from it.

Kleinenberg's speculations as to the physiological significance of the large ectodermal cells and their fibre-like processes are full of interest. These processes alone possess contractility, the cell-bodies belonging to them being entirely passive during the motions of the animal. He does not think that we can compare morphologically the tissue thus formed to the known tissues of any other animals, or that we can recognise in it physiologically

only one function. It appears to him as the most logical view to regard this tissue of the ectoderm of Hydra as the lowest stage of development of the nerve-muscle system in which an anatomical differentiation of the two elements, as this occurs in all the higher animals, has not yet taken place. Every cell is thus the bearer of a double function, those parts which constitute the long processes and lie upon the inner side of the ectoderm being contractile and performing the function of muscles, while the cell-bodies from which these proceed, and which stand in immediate relation to the surrounding medium, receive the stimulus and by transference of this upon the processes effect the contraction of the latter; in other words, they operate as motor nerves. He proposes, therefore, for these cells the name of "nervo-muscle cells."

If these views be accepted, a step will at once be gained towards the solution of one of the most important questions with which modern physiological research has occupied itself, namely, the nature of the motor-nerve terminations throughout the animal kingdom. While, however, we freely admit the care with which our author has worked out the structure of the parts, and the consistency of the views which he has founded on such structure, we cannot regard these views as supported by reasons so strong as to induce us unhesitatingly to accept them. Kleinenberg supports his doctrine on the assumption that nerve and muscle are correlative and inseparable. The fact, however, of our always finding them so associated in the higher animals affords no proof of such a connection being necessary in the lower, while the direct morphological continuity of nerve and muscle has not been established by any of the repeated histological researches which have been especially brought to bear on the elucidation of this very point. It is almost certain that the fibrillæ in the hydroid body constitute a contractile tissue; but that the superficial cell-stratum, from which Kleinenberg regards them as direct prolongations, represents a true nervous system, is still nothing more than a reasonable hypothesis.

The sketch now given of Kleinenberg's researches into the anatomy of Hydra will show that, while he has confirmed many of the statements of former observers, he has shown the incorrectness of others, and has, at the same time, advanced our knowledge of the animal by the discovery of several new and important points in its structure.

He next takes up the subject of development, and here his memoir is even richer in new facts and deductions than that part of it which dealt with the anatomy.

With regard to zooidal development as presented in the well-known budding of Hydra, we find nothing of importance added to the facts already known. But in the formation of the sexual organs and in embryonal development we have a series of most careful researches, which have elicited many unexpected facts and thrown new light on the entire subject.

It has been long known that at certain seasons there are found on the body of Hydra pustule-like swellings, which were regarded by the earlier observers as the result of a diseased condition of the animal. Ehrenberg was the first to detect their true nature when he showed them to be sexual organs—in some cases containing spermatozoa, in others ova; in other words, they are the testes and the ovaria of the Hydra, and the mode of formation of these and of their contents have been carefully followed by Kleinenberg.

According to him the formation of the organ on which the preparation of the spermatozoa devolves commences by a more active growth of certain cells of that part of the ectoderm which has been already described as the "interstitial tissue." This change is limited to roundish, circumscribed spots; the cells enlarge considerably, and assume the form of polyhedral plates, their protoplasm becomes clearer, and the spherical nucleus comes out distinctly. Then they repeatedly divide and pass into small, irregular, apparently amœboid cells, which become closely pressed together so as to form a compact lenticular body. This is the testis. It becomes gradually elevated into a conical projection, with its summit produced into one or two papillæ. In this state it is invested by the other element of the ectoderm (nervo-muscular tissue), whose cells have here become so much atrophied that only a thin protoplasmal layer remains of them as an external covering of the testis.

In the mean time the nuclei of the testis cells break up into numerous dark corpuscles, which soon disappear, and in their place sharply-contoured, strongly refringent corpuscles make their appearance. The cells then become converted into little clear, spherical bodies, and it is out of each of these that the spermatozoon is developed. On some one spot of the surface of the sphere there is formed a fine process of protoplasm which soon exhibits active undulatory movements. The time for the separation of the mature spermatozoon from the mother cell has now arrived, the cilium is found to be in union with one of the bright corpuscles in the interior of the cell, and by its strong undulations, the corpuscle with its attached cilium is extricated as a mature spermatozoon from the formative cell, which then becomes

dissolved. In this way the whole of the included tissue of the testis becomes converted into spermatozoa, which are ultimately discharged through an opening in the summit.

The formation of the ovarium—which is usually associated with the testes in one and the same individual—is next described. The interstitial tissue is here also the basis in which the new structure originates. Within a zone which embraces about half the circumference of the body, the cells of this tissue become multiplied and accumulated into groups composed each of a single layer of cells. These cells now increase in size, the groups come into union with one another, and there is thus formed between the endoderm and the superficial cells of the ectoderm an elongated cellular plate. The cells which belong to the middle of this plate increase still further in size; in their protoplasm there appear numerous, strongly refringent corpuscles, which collect about the nucleus, while the cells themselves become arranged in superposed series, which all converge towards a common central point, thus giving to the organ a striated appearance.

The organ thus formed is the ovarium. It must be admitted that in its mode of formation it differs essentially from the gonophores of the marine Hydroida. These are, in all respects, genuine buds, possessing a true zooidal independence, while the spermatozoa-producing and ova-producing bodies of Hydra can scarcely be regarded otherwise than as mere organs. Hydra would thus seem to offer an exception to the universality of the generalisation that the preparation of the generative elements among the Hydroida devolves on special zooids. Kleinenberg sees this difficulty, and meets it by the ingenuous supposition that in Hydra the sexual individual represents the gonophore of other hydroids, while those hydra-buds which reach maturity without developing generative elements correspond to their non-sexual or nutritive zooids.

Another very important point of divergence between the account given by Kleinenberg of the origin of the sexual elements and that maintained by other observers will be found in the seat of their origin being here assigned to the ectoderm.

My own observations on the origin of the sexual elements in the marine hydroids are, on the contrary, quite in favour of their being products of the endoderm. In these hydroids their first foundation shows itself as a thin, homogeneous stratum, lying between the endoderm and ectoderm of the manubrium of the gonophore, and it must be admitted that as yet we have no grounds for referring this to the one membrane more than

to the other. From this mass the ova or spermatic cells become differentiated; it increases rapidly in volume, and this increase appears to take place from additions at the side which is in contact with the endoderm, thus leading to the conclusion that additions are made to it by continuous transformation of the endodermal tissue. It is at all events certain that the generative elements are developed from it in a centrifugal direction, so that the more mature ova or spermatozoa are always found towards its ectodermal surface, and the nearer we approach the endoderm the more immature does the entire tissue appear—a state of things which though not absolutely conclusive as to the endodermal origin of the generative tissue, is most easily explained by regarding this tissue as so formed.

Another fact in favour of the same view is the occurrence of a delicate membrane which, in some cases, may be seen lying upon the outside of the mass of the ova and separating this from the surrounding ectoderm. This membrane I believe to be the "muscle lamella" of Kleinenberg much atrophied by the pressure of the included mass, and thus reduced to an extremely thin pellicle without any trace of fibrillæ. If so, it is impossible that the ova could have had their origin in the tissue of the ectoderm.

A still further argument in favour of the endodermal origin of the generative elements may be derived from the very exceptional condition presented by a few hydroids, and notably by *Sertularia pumila*. In this species ova are produced in the usual way within a sporosac. But besides occurring in the sporosac, they are also found in the walls of the blastostyle or columnar zooid from which the sporosac springs as a bud. These blastostylic ova, though probably originating, as in other cases, between the endoderm and ectoderm, are here deeply imbedded in the endoderm so deeply that they project into the cavity of the blastostyle, from which they are separated only by a very thin layer of the endoderm.

On the whole, the evidence, so far as the marine hydroids are concerned, appears in favour of the endodermal rather than the ectodermal origin of the generative elements. Kleinenberg, however, is very positive that in Hydra these elements are derived from the interstitial cells of the ectoderm. With his very careful observations and unexceptionable manipulations it is scarcely possible to believe that he has been led into error, and yet it would be a curious anomaly to find that so fundamental a difference in this respect lay between the freshwater hydra and its marine representatives.

The formation of the egg is next described, and here we

find several new and important observations. When the ovarium has attained the development just described, a cell, which usually lies almost exactly in the middle of the organ, attracts attention by its rapid growth. This is the young egg. It continues to increase in size and assumes a flattened shape with irregularly-lobed margin. With further growth it becomes divided by two deep indentations into two lateral halves united to one another by a central isthmus in which the nucleus (the germinal vesicle of the ovum) is imbedded. This nucleus now begins to increase considerably in size, and so also does the sharply-contoured nucleolus which is noticed within it. The nucleolus, however, after it has attained a certain size, disappears, and the nucleus now shows itself as a sharply, double-contoured vesicle filled with a very finely granular, weakly refringent mass.

The egg continues to increase in width, and the irregular lobes of its margin become more strongly developed. Its shape in this state with its two large, flat lobes and their connecting isthmus, is compared by Kleinenberg to that of a butterfly with its wings expanded and torn at their edges. In the germinal vesicle there now appears close under its membrane a clear, circular, flat body, the germinal spot.

In *Hydra viridis* chlorophyll granules now become developed in the egg, both in its central parts and in its peripheral lobes. As we know chlorophyll to be in Hydra a product of the endoderm, the ectoderm being entirely free from it, we are called upon to reconcile this fact with its appearance in the egg, which, according to Kleinenberg, is exclusively derived from the ectoderm. Our author anticipates this objection, and dismisses it with the remark that it only shows that the egg long before the occurrence of fecundation has liberated itself from the physiological tradition of the tissue in which it had its origin.

The marginal lobes and processes of the egg now greatly increase in size, extend further from the central protoplasm, become dichotomously branched, and form, in fact, the principal part of the egg. The shape of the egg thus becomes remarkably different from the ordinary one, and is stated by Kleinenberg to be "exquisitely amœbiform."

I can fully confirm Kleinenberg's statement of the irregularly-lobed condition of the egg in this stage, having, some years ago, noticed it very distinctly in *H. vulgaris*, but I feel very doubtful as to the propriety of designating this condition as amœbiform, a term which may tend to give an incorrect impression, as the processes cannot be regarded in the light of protrusible and retractile pseudopodia.

At the same time, peculiar structures make their appearance in the interior of the egg. In *Hydra viridis* these bodies present the appearance of sharply-coloured spherical corpuscles, which lie embedded in the protoplasm. When liberated and treated with diluted acetic acid, they are seen to possess a thick wall surrounding a cavity; the wall is flattened at one spot, and to the inner side of this is attached the base of a thick conical body, which projects deeply into the cavity.

It is these bodies which, according to Kleinenberg, have been mistaken by Ecker for embryonal cells, resulting from the segmentation of the egg. Kleinenberg, however, cannot regard them as cells; they take no direct part in the building of the embryo, and remain as intercellular form-constituents, which have manifestly the signification of material reserved for future use; they become gradually broken up. He names them "pseudo-cells," and compares them to the so-called yolk-spherules of the eggs of vertebrata. The resemblance of these pseudo-cells of *H. viridis* to certain bodies which I have elsewhere ('Gymnoblastic Hydroids,' p. 59) described as occurring free along with the eggs in the gonophore of Antennularia is very striking.

The formation of pseudo-cells continues until these bodies constitute a large proportion of the mass of the ovum. The egg has now attained in its greatest diameter the dimension of about 1·5 mm.; the projections of its edges are gradually withdrawn and become fused into the central mass, and the egg has assumed the form of a smooth, ovoid body.

About the time when the formation of the pseudo-cells is finished a retrograde metamorphosis begins in the germinal vesicle and spot which finally results in their disappearance. It is here of importance to notice that the germinal vesicle has disappeared without a trace long before the occurrence of fecundation. The egg has now replaced nearly the whole of the original ovarium, and is closely invested by the outermost layer of the ectoderm.

From the account now given it will be seen that the egg is developed out of a single cell of the ovarium, that it maintains to the last its morphological value as a simple cell, differing from the other cells of the ovarium by its independent growth and development—an important fact in its relation to the essential nature of the egg, and in its bearing on the general question as to whether the completely formed animal egg is a simple cell or a compound structure.

Soon after the disappearance of the germinal vesicle the time arrives when the egg is to escape from its confinement. An opening is formed in the summit of the membrane within

which it is included. Through this the soft, protoplasmic substance of the egg is gradually forced out, and finally the whole egg has been expelled.

The naked egg still holding on by a narrow point to the remains of its former covering is now fecundated, the testes discharge their contents, which become distributed through the surrounding water, and the spermatozoa come in contact with the egg and fix themselves by the head to its surface, but they were never observed to penetrate its substance.

After fecundation the process of segmentation sets in. This is preceded by the occurrence of two or three delicate pseudopodia-like processes on that spot of the egg which is diametrically opposite to the point by which it still adheres to the body of the Hydra, and, at the same time, a shallow depression shows itself between them. This depression deepens into a narrow groove, which gradually extends through the substance of the egg down to its base, and thus the division of the egg into two germ-cells is completed. During this process the bottom of the groove is seen to be set with pseudopodia, which present their characteristic movements of protrusion and retraction.

The entire process from the first appearance of the groove to the complete division lasts from two to two and a half hours. The protoplasm of the two germ-cells shows very lively movements, and the second cleavage now begins. This commences from the opposed surfaces of the two first-formed cells: it lasts from three to three and a half hours, and the egg thus becomes divided into four germ-cells; during the process the formation of pseudopodia is still more marked than during the first cleavage; it occurs chiefly on the surfaces of division. The cleavage thus continues in the usual binary order, and after the fourth cleavage is completed the egg has assumed the "mulberry form." It subsequently becomes quite smooth—the result not of the smallness of the cells composing it, but of the filling up of the interspaces between the cell boundaries.

After the completion of the segmentation two forms of germ-cells may be distinguished: one of these, consisting of prismatic cells, constitutes a single layer, forming the surface of the germ; the other set consists of polygonally flattened cells, and forms its inner main mass. These cells are all naked protoplasm masses, and at first show no trace of nuclei; a nucleus is subsequently formed in each, and this arises independently of any pre-existing form element.

A long discussion here ensues as to the essence of cell-

division and the nature of protoplasm movements, in which the author contends that the essential distinction between proper contractility as presented by muscle, and the movement which shows itself in every other form of protoplasm, consists in the fact that muscular contractility is essentially a motion in definite directions, consisting solely in a shortening of the muscle simultaneously with an increase of its transverse section; while in every other form of protoplasm—in an amœba, a connective-tissue particle, &c.—every molecule of its mass is moveable in every direction; and since we know that the all-sided mobility is a property of the indifferent protoplasm, we must regard muscle-substance as a modification of this, in which there has occurred a peculiar arrangement of the molecules, which excludes all movements but one.

The views of botanists and animal physiologists regarding the nature of cell-division are discussed at length; and in opposition especially to the hypothesis of Hofmeister, who maintains that cell-division is identical with the formation of drops in a liquid, Kleinenberg regards it as having its origin essentially in a destruction of the uniformity of the protoplasm, local differences in the cohesion of the mass setting themselves up; in some places the molecules attract one another more strongly, while in others the uniform weak attraction is maintained; and this cohesion-difference will induce a general or local change of position of the molecules relatively to one another. If we designate by the name of currents the continuous movements of a mass of protoplasm, which are the result of cohesion-differences, we may distinguish in the Hydra egg two forms of currents: 1, those which show themselves in the formation of local and superficial pseudopodia; and 2, currents which change the whole form of the egg. He thinks it very probable that the same forces which cause the currents cause also simultaneously the division; and he thus regards the division of the cell as a protoplasm-current phenomenon.

A very important process in the development of the Hydra germ next begins to show itself. This is the formation of the external covering or shell of the germ. In *Hydra viridis* this is first seen as an exceedingly thin structureless pellicle, which invests the free ends of the prismatic cells, which, as we have already seen, form the surface of the germ. This pellicle sends in short processes between the cells, and extends uninterruptedly over the whole surface of the germ, from which, by maceration in acetic or very dilute chromic acid, it may be separated as a continuous membrane. The formation of this first pellicle is followed by that of a second

beneath it, then of a third, and so on, so that at last the germ, instead of being surrounded by a layer of naked prismatic cells, is surrounded by a thick laminated hard shell of chitine.

After the outer shell is thus formed there is produced between this and the closely-applied germ a second covering consisting of a colourless, transparent, and very elastic pellicle. Of the origin of this Kleinenberg can say nothing positive, though he thinks it probable that it is caused by the hardening of a liquid secreted between the germ and the first-formed shell.

Kleinenberg has convinced himself that the outer germ-shell of Hydra is not due to the secretion and subsequent hardening of a liquid, but that it consists in a total metamorphosis of the entire outer cell-stratum of the germ. Every one of its component elements is thus a cell, which, as the result of the conversion of its protoplasm into chitine, loses its vitality, its proper physiological value, yet retains its morphological equivalence. The shell is therefore an epidermal formation, and in relation to the entire germ is one of its tissues.

The outer germ shell in *Hydra vulgaris* differs in some important points from that of *H. viridis*, for instead of the thick shell, with its smooth surface, which occurs in the latter, it consists in *H. vulgaris* of a thin chitinous capsule, which is set round with a multitude of irregular spines mostly cleft at their free extremities. This peculiar form is due to the origination in each of the superficial prismatic cells of a large vacuole immediately below the free surface of the cell, the rupture of the cells over the vacuole, the fusion of several vacuoles into one, the consequent formation of a sort of labyrinthine tissue, and the conversion of this into the chitinous shell.

It appears, then, established that the first differentiation of the germ of Hydra consists in the formation of a peripheral cellular lamina, the protoplasm of whose cells becomes converted into chitine, and thus forms a solid shell. The first organ which is developed from the germ is thus a provisional embryonic one, which takes no part in the formation of the definitive body, and on the liberation of the young is simply cast off.

The period of the proper embryonal development takes a far greater time for its accomplishment than has been needed for the processes just described. While the whole of the processes from the first appearance of the egg to the completion of the germ-shell are mostly completed on the fourth

day, from this to the liberation of the young animal embraces a period usually extending over six to eight weeks.

The first event which occurs during this period is a very remarkable one. After the completion of the shell the boundaries of the cells composing the mass of the germ become indistinct and are finally effaced, the cells themselves have become fused together, and the germ is once more like the unsegmented egg, a single continuous mass of protoplasm. This is filled with pseudo-cells, albumen granules, and, in *Hydra viridis*, with chlorophyll granules. So enormous a histological retrogradation might lead us to suspect its reality, but Kleinenberg has no doubt of it, and he refers to analogous cases, such as the currents in the protoplasm of Myxomycetes, which show that the cells from which this protoplasm originates have entirely lost their individual distinctness; while even among the higher animals he can adduce the observations of Bischoff as to the dissolution of the germ-cells in the guinea-pig and the roe-deer. As it is quite certain, however, that this phenomenon does not occur in other hydroids, it can have no general significance for the development of the order.

In the uniform protoplasm mass thus produced there is next formed a small excentric cavity. This is the foundation of the body cavity. By the solution of the surrounding protoplasm it increases in size and becomes nearly uniformly developed within the germ; it is filled with a clear liquid. There is thus formed a closed sac—the germ-sac.

It is clear that the formation of a body cavity by invagination of the walls, with the significance which Kowalewsky has assigned to it in other animals, does not exist in Hydra, and just as little will it be found in any other hydroid.

In the condition now described the germ-sac remains for several weeks. In the meantime the outer germ-shell loses its firmness, and is finally burst by the expansion of the contained germ, which now escapes into the surrounding water, covered only by the transparent, elastic, inner shell.

A further important change next occurs in the germ-sac. The pseudo-cells which had previously been distributed throughout the whole thickness of the walls of the sac have uniformly withdrawn themselves from the surface, so that the sac now presents a clear superficial zone. This is the first indication of the splitting of the walls into the two definitive germ-lamellæ. The clear superficial zone is to become the ectoderm, the darker zone which lies beneath is the endoderm.

The thickness of the clear outer zone gradually increases, and cells now become differentiated in it. These are the

nervo-muscle cells. The interstitial tissue subsequently shows itself between them in the form of irregular or fusiform cells. The embryo stretches itself out, and assumes an ellipsoidal figure; its walls become thinned at one end, where a stellate cleft suddenly makes its appearance. This is to become the mouth. Simultaneously with the appearance of the mouth the foundation of the tentacles has been laid in the form of tubular offsets of the body cavity. That layer of the body walls which is to form the endoderm remains as a stratum of continuous protoplasm until after the formation of the mouth, when we find it converted into a layer of prismatic cells. The thin inner shell which had continued to invest the embryo after the destruction of the outer one now becomes softened and dissolved, and the young animal is set free, corresponding in all respects except in size with the adult, all the tissues having differentiated themselves to their definitive form, and even the thread-cells, though still few, being already ripe for emission.

From what we have thus seen of the development of Hydra it is evident that this animal passes through no proper larva stage. It differs in this from all other known hydroids. We know that the egg of every other hydroid—if we except that of the monopsean medusæ—becomes directly developed either like Sertularia into a planula, or like Tubularia into an actinula. A certain resemblance between the young Hydra and the young Tubularia induced me to include the early free stage of both under the name of actinula. As it appears now, however, that Hydra passes from the condition in which it first becomes free to its adult state by continuous growth without any true metamorphosis, I accept, so far, the justice of Kleinenberg's criticism, and believe with him that the term actinula is not strictly applicable to it. It is otherwise, however, with regard to Tubularia. Here we have a true metamorphosis, and the young is a free larva which undergoes important transformations before it becomes converted into the fixed adult. The term actinula is thus a convenient designation for the larva of Tubularia and of the apparently similar larva of Myriothela, and in this sense I have employed it in contradistinction to the term planula, by which the earliest free stage of other hydroids had been already known.

I would accordingly distinguish three different modes in the development of the hydriform trophosome:

1. The development subsequently to the liberation of the young animal takes place by continuous growth without any metamorphosis. This mode exists in Hydra alone.

2. The development takes place by a true metamorphosis, the hydroid passing through the larval form of an actinula. Of this Tubularia affords an example.

3. The development takes place by a true metamorphosis, the hydroid passing through the larval form of a free ciliated (or non-ciliated) planula. Of this we have an example in Sertularia.

A comparison of the embryonal development of Hydra with that of other hydroids shows that while in some respects important differences are apparent, yet that in all the more essential features there is a complete agreement, and by widening the comparison so as to embrace in it what we know of the development of the higher animals we arrive at certain comprehensive generalisations which include not only the Hydroida, but even the highest members of the animal kingdom.

Huxley was the first to point out the equivalence of the ectoderm and endoderm of the Cœlenterata with the outer and inner germ-lamellæ of the vertebrate embryo, and this important generalisation is fully confirmed, not only by the development of hydra, but by that of all other hydroids whose development has been carefully studied.

There are many groups of the animal kingdom of whose developmental history we as yet know little or nothing, but all which have been studied with anything like completeness —all at least above the Protozoa—show that the germinal matter which results from the segmentation of the ovum differentiates two concentric germ-lamellæ out of which the whole animal body is built up. In animals above the Cœlenterata there is further formed between the outer and inner germ-lamellæ a middle germ-lamella, but whether derived from the outer or the inner remains an unsettled point. This middle lamella is not formed in the Hydroida unless, as Kleinenberg with considerable reason supposes, it be represented by the fibrillated layer or muscular lamella, and as there can be no doubt that this really belongs to the ectoderm, an argument is afforded in favour of the middle lamella being a derivation from the outer. The muscular lamella, however, is not in the Hydroida an independent layer; but, as Kleinenberg has shown, passes continuously into the superficial cells of the ectoderm. The ectoderm should thus be regarded as the united outer and middle germ-lamellæ of the higher animals.

It should be noted that the study of hydroid development proves that the digestive cavity is here formed by a simple hollowing out of the interior of a solid germ, the mouth subsequently making its appearance by a rupture of the

walls of the sac-like body thus formed, and not, as maintained by Kowalewsky and Semper, in nearly allied animals, by an invagination of the walls.

Another question of great importance in this inquiry is how far the origin of the various tissues and organs in the respective germ-lamellæ corresponds through the several groups of the animal kingdom. We know that in the Vertebrata there are formed from the outer lamella, the great nerve centres and organs of sense, and the epidermal structures; from the middle lamella the muscular, skeletal, and vascular systems; and from the inner lamella the lining of the digestive system and the glands connected with it. Opinions vary as to the original seat of the generative system.

Now, accepting the view that the ectoderm of the Cœlenterata represents the united outer and middle germ-lamellæ of the higher animals, and accepting also the hypothesis that the superficial cells of the ectoderm in Hydra with their processes represent a nervo-muscular system, we shall find a remarkable correspondence as to the origin of the specialised tissues between the Hydroida and the Vertebrata. In the Hydroida the tissues are few, but these few are similar in their origin from the primitive embryo layers to the equivalent tissues of the higher; for the nervo-muscular tissue of the Hydroida has its foundation in the ectoderm, which is equivalent to the united outer and middle germ-lamella, while the digestive surface is plainly formed by the endoderm or inner germ-lamella. Here as in the higher animals, the origin of the generative system is still an open question, and it is probable that it is not in every case derived from one and the same lamella, for while Kleinenberg is very certain of having traced it to the ectoderm in Hydra, my own researches are in favour of its endodermal origin in other Hydroida.

A still further interesting point of identity follows from Kleinenberg's discovery of the origin of the germ shell in Hydra. This chitinous investment he shows to be a true epidermal structure formed by the entire conversion of the most superficial cells of the germ at a very early period in the development; and then entirely cast off after remaining for a time as a transitory embryonal organ.

We have thus exactly, as in the Vertebrata, the most superficial portion of the outer germ-lamella developing an epidermis whose very early appearance and transitory nature are the only important points in which its history differs from that of the epidermal layer in the Vertebrata.

It is true that nothing of this kind can be detected in the

other Hydroida; in these the superficial ciliated cells of the planula almost certainly pass into a permanent constituent of the body walls, while the chitinous perisarc is not a tissue at all, but a mere hardened excretion from the surface. I regard the perisarc, notwithstanding its persistence, as homologous with the internal germ shell of Hydra; indeed in some species (*e. g.*, *Eudendrum ramosum*) we find it forming a closed sac in which the whole of the young hydroid continues to be included even after the appearance of the rudimental tentacles exactly as seems to be the case with the inner germ shell of Hydra.

There is thus a difficulty in applying Kleinenberg's deductions to the marine Hydroida and regarding the superficial cells of these as the representative of a nervo-muscular system, for we should then be compelled to derive the nervo-muscular system of these hydroids from that part of the outer germ lamella which in the Vertebrata gives origin to the epidermal structures, and thus reduce to a mere non-essential resemblance the parallelism which appears in other respects so well established between vertebrate and cœlenterate development.

When we bear in mind that the embryonic condition which shows itself in the presence and primary relations of the germ-lamella becomes soon lost during the process of development of the higher animals, while the outer and inner germ-lamellæ with their relations to one another and to the surrounding world are retained as ectoderm and endoderm through the life of the Cœlenterata we at once see wherein consists the low position of the Cœlenterata in the animal kingdom, and can compare the permanent Cœlenterate type with an early stage in the development of the higher animals.

It will be seen from the account now given that the researches of Kleinenberg have resulted in some very valuable additions to our knowledge of the structure and life-history of Hydra. In some respects they differ from those made by myself on the same animal; but as my opportunities of investigating Hydra have been comparatively few, while such examination as I was enabled to make were not aided by the very reliable methods adopted by our author, I am not prepared, at least in the absence of additional observations undertaken with the view of verification, to defend them, and am willing to accept, not only those points of the memoir which agree with my own conclusions, but most of those also which take a different view.

On the Motion Accompanying Assimilation *and* Growth *in the* Fucaceæ. By Prof. P. Martin Duncan, M.B., Lond., F.R.S., &c. (With Woodcut.)

(Read in Section D, at the Meeting of the British Association at Bradford, 1873.)

How do the dark olive-coloured Fucoids respire? and whence do they obtain their recondite elementary belongings? are questions which most physiological botanists have asked themselves during their sea-side rambles. Authority answers readily enough respecting the respiration, and will probably insist that the nitrogenous and non-nitrogenous combinations, the iodine, bromine, the potash, soda, and the phosphates are separated from the sea-water in which they all exist as inorganic substances. It is assumed that the plant exercises a selective function, and that the rushing wave yields up the elements in binary compounds to the superficial cells. These can alone be the agents of the nutrition of the plant, for there is no true root and no special circulatory system. Washed by the sea, the cell-wall permits of an endosmosis, and a liquid enters which is barely salt, and which contains the well-known ultimate principles of these cellular plants. Were the colouring matter of the Fucus green, and were its proximate compounds only combinations of C,H,O, and C,H,O,N, the effect of light and life on the carbonic acid and free ammonia in the sea water would be deemed sufficient to account for the assimilation.

But the colouring matter is peculiar. The plants may be exposed to the glare of the sun, or hidden in cavities where there is ever a gloomy darkness, with the same result on their pigment. The presence of sufficient ammonia in sea-water to account for the weight of nitrogenous matters in the rapidly growing Fuci is a myth, and it is quite as probable that decaying Fuci contribute the small percentage of salts of iodine and bromine to the sea as that they should enter the plant in solution in pure sea water.

The Fuci like the shore, and live best where the waves are saturated with air, and doubtless much of the nitrogen may come from this source. Is there not another? is a question which commends itself, and which may be answered by a second: why should not these plants without green chlorophyll[1] absorb organic matter in a state of solution? matter

[1] [Millardet has detected chlorophyll in *Fucaceæ*, 'Comptes Rendus,' Feb. 22nd, 1869.—Eds.]

consisting of carbon, oxygen, hydrogen, and nitrogen, with other elements,—such matter as is absorbed by animals and by entities which have irritability and powers of motion, but whose position in the sub-kingdoms is uncertain. That there is abundance of such soluble matter not yet resolved into its ultimate elements, floating in the sea, no one can deny. Wyville Thomson found it deep in the Atlantic, and every excreting marine animal and plant contributes some of it. Evanescent it probably is, but its amount must be enormous.

Whilst thinking over such heresies as these, some other and contingent probabilities suggested themselves. For instance, if the dark-coloured Fuci absorb this organic solution—animal-like—do any amœbiform motions accompany the assimilation? and what is the cell-growth like? It is hopeless to manipulate the superficial cells of *Fucus vesiculosus* with a view to examine into their method of growth and assimilation; but the so-called "conceptacles" on the clavate ends of the fronds, which contain both round oogonia, and a vast number of extremely delicate finger-shaped processes composed of a succession of cells, yield admirable examples.

Each hollow enclosed by the frond, or the conceptacle, is full of oogonia, and of the dactylose processes, bathed in a glairy homogeneous viscid colourless fluid. Growth progresses very rapidly in these structures, for the cells are extremely delicate, and it is evidently due to the direct assimilation of the mucus-like fluid which bathes them.

The following observations were made on a hot and light day in August, upon the growth of the terminal cells of two sets of finger-shaped processes:

After removing several conjoined processes, and placing them in sea water mixed with the mucus upon a glass slide, due precautions being taken to prevent pressure of the thin glass cover, the relative position of the tops of two processes was carefully noticed and drawn.

One process (a) had a fine tapering cylindrical terminal cell surmounting a proximal cell (a'). The other process (b) had a short and stout terminal cell, the distal end of which was exactly on a level with the base of the terminal cell of the other process, a.

Four prolonged examinations of these cells occupied three quarters of an hour, and during that time important amounts of assimilation and growth occurred.

At the commencement of the observations the condition of cells a and a' (see woodcut, fig. 1) was as follows:

The terminal cell (a) had a homogeneous thin and very

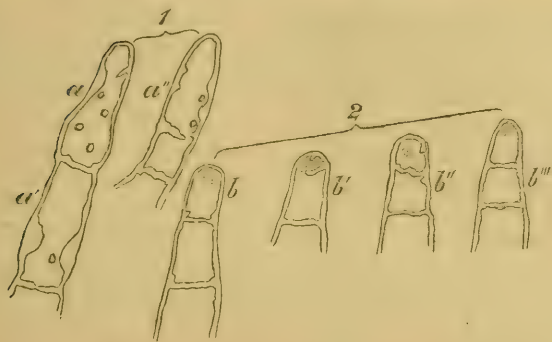


FIG.

1. Two cells of a process in the conceptacle of *Fucus vesiculosus.*
   - *a.* Distal cell.
   - *a'.* Proximal cell.
   - *a''.* Appearance of distal cell after $\frac{3}{4}$ hour.
2. Two cells of another process.
   - *b.* Distal cell, with its top on a level with the intercellular wall of process 1.
   - *b'.* Appearance and position of the distal cell after $\frac{1}{4}$ hour.
   - *b''.* " " after $\frac{1}{2}$ hour.
   - *b'''.* " " after $\frac{3}{4}$ hour.

The object-glass was a good penetrating $\frac{1}{4}$-inch.

transparent cell-wall, and its contents were, 1, a homogeneous protoplasm less transparent than water; and 2, four refractile circular granules.

The cell-wall gave for the most part the usual double line under the microscope; but here and there the external line was alone apparent, the inner being represented by a curve in one place and by a sharp inward bend in another. The substance included between the external straight line and the curved line was homogeneous, but had a different refractibility to the rest of the cell contents.

In the lower cell (a') two large incurvings of the cell-wall were noticed, and the wall between the cells was single, and presented two lines to view, the ends of which, where they joined the outer cell-walls, were slightly curved.

The top of the second process (fig. 2, *b*) was exactly on a level with this intercellular partition.

There were no refractile granules in the distal cell (*b*) of this second process, and its cell-wall had a double line throughout. The contents of the cell were a transparent homogeneous protoplasm, and a portion of more opaque structureless material quite at the end.

After the lapse of a quarter of an hour the distal cell just

mentioned had its top slightly beyond the level of the intercellular wall of the first process. The opaque spot had increased in size, and there were two places where the outer line of the cell-wall was in its normal curve, whilst the inner was sharply bent inwards, so as to encroach on the interior of the cell (b'). Both were in the immediate neighbourhood of the opaque spot, the longest of the two bounding it below.

In a second quarter of an hour the longest of the bends had reached across the cell in a slanting direction, and had united with the opposite wall (b''). The smaller curve had increased so as to separate the lines of the cell-wall for some distance, and the opacity had diminished. The top of the cell was further in advance of the intercellular wall of the first process.

In the third quarter, and at the expiration of three quarters of an hour from the beginning of the observations, the new cell-top had grown far in advance, and had become very considerably rounded (b'''), whilst slight irregularities in the direction of the inner line of the wall were noticed in it and also in the lower cell.

During this lapse of time the first process (fig. 1) had grown in length, and the distal cell (a) had altered considerably in its details. The curve in the inner line of the cell-wall had diminished, but a large and conical one had reached the opposite cell-wall, thus forming a dissepiment and dividing the cell into two (a''). Moreover, irregularities in the contour of the inner wall existed in the opposite side to those just noticed; the refractile granules were not so numerous, and the whole cell had increased in breadth as well as in length. The so-called curves could be noticed to change their form by a slow undulating movement, which was singularly suggestive of the method of movement of Amœba, and it was evident that the motion extended beyond the curve amongst the more mobile included protoplasm. There was no trace of gas bubbles around the cells, and the elongation, increase in bulk and the molecular changes were not attended by any visible chemical action.

The impression left on the mind was that the cell-wall was merely a more solid condition of the protoplasm of the cell, and that the movement was determined by portions of it returning to their more fluid state, owing to the transmission or absorption of the surrounding medium.

Could one of the cells have been removed from the contact of the others, it would have greatly resembled a Protamœba in movement within a homogeneous tissue. Movements like these are not observed in most algæ which are

nourished in water where organic matter in solution does not exist. It becomes, then, a matter of some interest to attempt to connect such movements and such cell-growth with nutrition by such organic matter as would be assimilated by low animal forms.

On RHABDOPLEURA MIRABILIS (M. Sars). By GEORGE OSSIAN SARS. (With Plate I.)[1]

IN the year 1866 I dredged, together with other deep-sea animals, from a depth of 120 fathoms at Skraaven in Lofoten, a small "Phytozoon," to which at first I paid no great attention, as I took it to be a colony of Hydroids; I took, therefore, only a few specimens, and put them in spirit with some other uncertain forms of animal life from the same depth. After my return home, however, on examining more closely this supposed hydroid colony, my father found immediately that we had before us a very peculiar animal, which quite certainly could not be a Hydroid, but seemed rather to be related to the Polyzoa; although the shape and appearance of the single cells had undeniably a great resemblance to the former, especially to some Campanularides. As a satisfactory examination of the animal could not be made with the specimens brought home in spirit, my father urged me, the next time I visited Lofoten to examine the animal in a living state as minutely as possible, as we should without doubt obtain interesting and instructive results. This I had an opportunity of doing in the following year 1867; and I then examined, as carefully as possible with the instruments at my disposal, the structure of this fragile little animal, which I found peculiar in the highest degree, and different from all that I had previously known. My father was greatly surprised on learning the result of my examination, and, looking over the numerous drawings which I had made from the living animal, it was clear that we had before us not only an entirely new genus and family, but even the type of a still higher division; and we found no small difficulty in referring it to any known animal type. But as it appeared most nearly related to the Polyzoa, my father classed it with these, and noted it in his catalogue of deep-

[1] Reprinted from 'The University Programme' for the first half year, 1869. Christiania, 1872.

sea animals, compiled in 1868, as *Halilophus mirabilis*[1] (the generic name taken from a certain resemblance of the tentacular arms to the so-called lophophore of the fresh-water Polyzoa). The next year appeared Allman's treatise on *Rhabdopleura*, a new form of Polyzoa, from deep-sea dredging in Shetland;[2] and my father, as well as myself, at once recognised in the species therein described and delineated, *R. Normanni*, a form closely agreeing with the *Halilophus mirabilis*, but which evidently, from the form and attachment of the polyzoarium, must belong to a different species from ours. Allman's communications concerning the organisation of the animal show indeed, as will appear from the sequel, many essential differences from what I have had occasion to observe in our northern form; so that if these communications were in reality correct, there could scarcely be any doubt that both forms were also generically distinct. But the fact is that Allman has only had the opportunity of examining specimens preserved in spirit; and both my father and myself know from experience how extremely difficult it is to obtain results with specimens in this state, and what imperfect and false notions may thus be formed of the animal's real structure. Taking this into consideration, we may really be astonished that Allman has been able to see so much as he actually has seen, and that he has not misunderstood the animal's organisation in a greater degree than appears from his description and delineations. Allman has indeed seen in the *Rhabdopleura* a very aberrant form of Polyzoa, but is far from having apprehended that the form is abnormal in so high a degree as it has proved to be according to investigations which I have executed with the utmost care and minuteness.

With respect to the method of examination, there is little or no use in dissecting so small and fragile an object as the animal of the *Rhabdopleura*, even if the finest imaginable instruments are employed. It is, therefore, necessary to study the animal entire, or at most, after separating the individual animals from their cells or tubes, which, as will be seen, may be done with the greatest ease in operating on the living colony. In order to get a sharper and better view of certain parts, I have found it very useful to effect a gentle compression of the animal between two glass plates, so that the pressure can be moderated at will. I cemented a thin

[1] 'Forsatte Bemærkninger om det dyriske Livs Udbredning i Havets Dybder,' p. 12.

[2] 'Quarterly Journal of Microscopical Science,' vol. ix, 1869, pp. 57—63, pl. 8.

glass plate to the upper arm of my compressorium, by which means the desired result was obtained far better than by the use of the so-called "aquatic boxes." Moreover, most of the parts of the living animal may be easily examined without pressure, and without even taking the animal out of its cell. A colony, or part of one, can be placed under the microscope, and the most important parts will plainly be seen through the transparent walls of the cells, even if the animal has not stretched itself out of the aperture.

Besides the outer chitine-like tube, with its off-shoots or cells (polyzoarium), there may be distinguished in the animal under consideration the following principal parts:—1. The *polypide* itself, which again shows three principal parts—(*a*) the body; (*b*) the tentacular arms; and (*c*) the buccal shield; 2. the *contractile cord;* and 3. the *axial cord.* I shall treat each of these parts separately.

The polyzoarium (cœnœcium) in the *Rhabdopleura mirabilis* (see Pl. I, figs. 5 and 6) has the form of a thin, elastic, flexible, chitine-like, transparent, most frequently quite colourless, cylindrical hollow tube, consisting of a *stem,* which creeps along the bottom of the sea, now and then attached to other bodies, irregularly winding, and only seldom, here and there, forked, which at short intervals sends up perpendicular, free, undivided, more or less winding *branches,* of the same form, calibre, and nature as the stem, and all terminating with a circular aperture. A difference between the stem and the branches strikes the eye immediately; the stem is always more or less thickly covered with extraneous particles (sand, mud, fragments of shells, Rhizopod-shells, &c.), while the branches are always, with exception of the very lowest piece, quite free from such particles, and consequently quite transparent, appearing in their whole extent very distinctly and ornamentally ringed. The rings, which are only exterior, form close, equidistant, sharp, circular transverse folds, strongly prominent over the surface of the tube, causing the edges everywhere to appear crenulated (see fig. 5). If one can separate from the stem the very closely adhering extraneous particles (which is effected with no small difficulty), it will be seen that this outer formation of folds is also continued on the stem itself, although far less sharply marked, and also more irregular, the transverse folds being often divided fork-wise, or in other words, not forming completely separate rings. It will also be remarked (fig. 6) that the branches of free tubes are not at all sharply distinguished from the stem, but that their interior cavity is prolonged immediately into, or

continuously with, the cavity of the stem. This latter, the interior walls of which, like those of the tubes, are quite smooth, is divided at certain intervals by tolerably thick transverse lamellæ, or septa, into several successive cylindrical chambers, which do not communicate with each other, but each one of which is continued immediately in one of the perpendicular tubes proceeding upwards from the stem. Through the whole of the creeping stem, extending along through all its chambers, runs a thin cylindrical chitinous cord (the axial cord), very remarkable from its dark, nearly black, colour, of which more hereafter. This cord is never continued up through the free tubes, but may now and then, rarely, divide itself fork-wise, namely, when the creeping stem divides itself in this manner.

Every one of the perpendicular branches or tubes contains an animal, which is connected by a long, cylindrical, fleshy cord (the contractile cord), near the bottom of the corresponding chamber in the stem, with the axial cord, which thus unites all the individuals of the colony with each other.

The creeping stem in the *R. mirabilis* may indeed attain a very considerable length, but it is very difficult to get the whole separated from the substances which adhere to it. One can usually, therefore, only get up small pieces of the colony, and seldom more connected portions. The largest connected piece of stem which I succeeded in getting loose from its attachment was about 40 mm. long, and was at irregular distances four times bifurcated; another piece was of about the same length, but only three times divided. These branches, which proceed from the stem at a more or less acute angle, are also creeping and irregularly bent, and, like the main stem, produce cells, the number of which in all on these pieces of stem amounts to about 60. The stem is thus only seldom branched, and usually runs to great length without producing any branch.

The cells or tubes, which proceed from the stem by lateral budding, are of very different length, while their thickness is everywhere, and in all, about the same. The largest are 6—7 mm. long and $\frac{1}{4}$—$\frac{1}{5}$ mm. thick. They are, as stated, erect, yet seldom, or never perfectly straight, but always more or less bent in some part, or in the whole of their length, sometimes like an S, sometimes in several bends or turns, like a drawn out screw, but most frequently irregularly bent, in rare instances so strongly curved, that the curve is nearly circular.

From the above description, it will be seen that the poly-

zoarium in the *Rhabdopleura mirabilis* is decidedly different from that of the Shetland *R. Normanni.* Firstly, the creeping stem of the latter, of which one surface everywhere adheres to old shells or other solid substances, is much more strongly branched ("subalternately"), and, like the cells, quite naked, without trace of attached extraneous particles. Then the cells themselves are not, as in our species, free in their whole length, but at the base for some distance, like the stem itself, fixed and creeping, for which reason also the free perpendicularly rising ringed part of the same is much shorter than in the *Rh. mirabilis.* Finally, there appears some difference between the two species with regard to the manner of the division of the stem into chambers.

The polyzoarium in the *Rhabdopleura* does not coincide with any other species of Polyzoa. The cells in their tubular form resemble most of those of the Cyclostomata, but are horny or chitine-like (in the Cyclostomata they are chalky), and are distinguished by their surface, covered with prominent transverse folds or rings, which are also foreign to the Polyzoa, but are found in many Hydrozoa, such as certain Tubulariadæ and Campanulariadæ.

The individual animals or polypides seem at first glance to resemble the ordinary Polyzoa (see fig. 5). *The body,* which is only a little over 1 mm. long, is oblong, and appears to be occupied almost entirely by the digestive system; on closer examination, we find, however (see figs. 1, 2, and 4), that a thin glassy skin surrounds the digestive apparatus, which therefore is not, as in all other Polyzoa, freely suspended in the "perigastric fluid," which latter, as will appear in the sequel, is entirely wanting in the *Rhabdopleura.* In all other Polyzoa, without exception, there is besides the so-called ectocyst, corresponding with the Polyzoarium, also a so-called *endocyst,* which always represents a thin membrane, lining the interior of the ectocyst or cavity of the cell, and, from the aperture, recurved and attached round about to the polypide, under the base of the lophophore. The interior cavity of the cells in the other Polyzoa is thus actually completely closed by the endocyst and the body of the polypide; and the so-called perigastric fluid therein contained, wherein the intestinal canal of the animal is freely suspended, does not stand in any direct connexion with the surrounding medium. The retraction of the polypide into the cell is effected only by a folding (invagination) of the anterior elastic part of the endocyst, by which the so-called tentacular sheath is produced. The case is quite different with the *Rhabdopleura. Here is no endocyst at all*

(unless we should consider the glassy skin which closely surrounds the digestive apparatus to be an endocyst), consequently also no perigastric fluid; and, further, the cavity of the cells stands in direct communication with the surrounding medium, without being closed at the aperture by a skin connecting it with the animal's body. The retraction and protrusion of the polypide is, therefore, not effected as usual by in- and evagination, but in a totally different manner, of which more hereafter. Allman has indeed (l. c.) imagined that he has perceived a trace of a real endocyst of the same nature as that observed in the other Polyzoa, but he has quite certainly deceived himself. The polypide of the *Rhabdopleura* lies quite free in the cell, and is only attached to the colony by means of the contractile cord, neither by any endocyst nor special muscles, as appears clearly enough from the fact that when the contractile cord is severed, the polypide can be taken entire and uninjured out of its tube with the greatest ease.

From the anterior part of the body where the mouth is situated, yet, as will appear in the sequel, not as usual in a terminal position, but rather in a ventral situation behind the peculiar oval prominence (the bucal shield), the gullet or *œsophagus*, rather short, but wide, and furnished with thick walls, proceeds right downward or backward to the stomach, from which it is separated by an also outwardly apparent constriction, and by a sort of internal valve (the cardiac valve).

The *stomach* (f), which is simple, without any armament of teeth or hard parts in its interior, and furnished with tolerably thin walls, is elongated, rounded cylindrically, slightly and somewhat irregularly curved, with ventral concavity, and in its anterior part, where it has its greatest breadth, only a little wider than the gullet, and occupying about two thirds of the cell's calibre. In the anterior half it is of about uniform thickness, but diminishes towards the posterior end (pylorus) very rapidly, and goes imperceptibly over, after turning a little to one side, into the intestine, suddenly curving itself upward and forward. The *intestine* (g), which is not by any constriction, nor yet by any interior valve (pylorus-valve), distinguished from the stomach, of which it forms the immediate continuation, is narrow, cylindrical (its thickness scarcely one third of that of the stomach in the widest part), only slightly tapering towards the end (see fig. 3), and has a tolerably straight course forward, lying close to the dorsal side of the stomach and gullet, and terminates with a circular anal aperture, situated just behind

the spot from which the tentacular arms proceed. Immediately behind the anal aperture, between the terminal part of the intestine and the dorsal wall of the gullet, which here forms a little concavity, there appeared a clear cellular body (fig. 1, r), in which several evident nuclei were visible. I cannot, however, pronounce any decided opinion as to the signification of this object; it can scarcely be a nervous ganglion, as it does not lie in the substance of the body itself, but only in the thin external skin which encloses the body. The stomach and the intestine usually show in the living animal a bright, opaque, yellowish-brown colour, which colour seems mainly to be derived from the contents. When the stomach and intestine are more empty, they shew a far paler yellowish-white colour. The walls of both show plainly a fine cellular structure.

It is evident that the digestive system in the *Rhabdopleura* differs, in many points which have not been remarked by Allman, from the normal system of the Polyzoa. In the latter the stomach usually consists, as is well known, of two distinctly separate parts, one shorter cylindrical cardiac part, and a longer and wider pyloric part, which ends in a large. rounded, bottle-shaped cæcum (cul de sac). Therefore the intestine usually takes its origin in these high up, or about on a level with the transition of the cardiac part to the pyloric part; while in the *Rhabdopleura,* where no such division of the stomach occurs, the intestine proceeds from the posterior end of the stomach or fundus, as the immediate continuation of the same.

The tentacular corona or lophophore, situated in the *Rhabdopleura* on the anterior end of the body, is of a totally different appearance from that of the other marine Polyzoa, while, on the other hand, it appears at first sight to show an unmistakable resemblance to that of most freshwater Polyzoa (*P. Hippocrepia),* and is also thus represented by Allman. However, when it more closely examined, it displays many essential differences, although by its strongly marked bilateral symmetry, it appears to be most nearly connected with the same, in respect of the semilunar or horse-shoe form peculiar to them.

As in the said freshwater Polyzoa, the lophophore or tentacular frame does not form a circular ring, but is drawn out into two lobes or arms, each of which bears a double row of tentacles. These lobes or arms (fig. 5, &c., d), which also here proceed from the dorsal side, are, however, considerably longer and narrower, or more cylindrical than in any other of the known Polyzoa; and while in those freshwater

Polyzoa they only form a part of the tentacular corona, they represent here the whole lophophore, as it is only on these arms that the tentacles have their place. The tentacles in the *Rhabdopleura* do not form, as in the other Polyzoa, a continuous series, but are interrupted, as well dorsally as ventrally, by an evident interval; in other words, *we have not one single tentacular crown, but two symmetrical tentacular arms,* which take their beginning on each side of the anterior part of the body, and extend out from the same dorsally and diverging to each side. If we examine these tentacular arms in the living animal, we find that they are also in many respects different from the lophophore of the Hippocrepia. While the latter always retain unchanged their form and somewhat inclined direction, the tentacular arms in *Rhabdopleura* are in a high degree flexible and variable in their direction relatively to the body of the polypide and to each other. As long as the polypide is withdrawn into the cell, they are always extended straight forward and nearly parallel with each other, forming, together with the tentacles attached to them, a close fascicle extending in the same line with the body. As soon as the polypide reaches the aperture of the cell, they spread out from each other, but this takes place in various manners. Sometimes they are bent with the ends only a little out from each other, while otherwise they are nearly parallel (see fig. 5); sometimes they spread themselves out so widely on each side that they stand almost diametrically opposite; sometimes they bend themselves with the ends downwards (see fig. 5); sometimes—and this is most usual, and always occurs when the animal is taken out of its tube—they are bent upwards and backwards, and that often so strongly that they describe a nearly semicircular curve, so that the extremities even touch the dorsal side of the polypide's body (fig. 1). This great mobility of the tentacular arms or lophophore (so different from what is observed in the other Polyzoa), which appears to be produced at will by the animal, sometimes in one manner and sometimes in another, must certainly, although it always takes place very slowly and with little energy, be brought about by means of auxiliary muscles or muscular tissue. I have, however, only succeeded in observing very faint traces of anything of the kind. When the animal is gently compressed between two glass plates, one may observe on each side some very fine fibres (figs. 1 and 2, p) passing obliquely over the gullet, proceeding from the ventral side, where the body of the polypide forms on each side a small conical prominence (ibid., o, o), which may per-

haps be considered as the ventral corners of the lophophore, and losing themselves at the root of the tentacular arms. They appear to represent the retractile muscles of the tentacular arms, which produce their flexion upwards and backwards. It has not been possible for me to discover any distinct trace of any such thin membrane connecting the basis of the tentacles (the so-called calyx), as is found in the fresh-water Polyzoa. As regards the *tentacles* themselves, they are, indeed, of the usual cylindrical form for Polyzoa, and are as usual furnished with cilia, but in the living animal they have a very different appearance from that of the tentacles in the ordinary Polyzoa. While in the latter they are always in the greater part of their length extended straight, forming a regular corona, which only slightly changes its form, the end of some one or other of the tentacles being only sometimes bent a little in one direction or another, the tentacles in the Rhabdopleura are always bent and curved in the most irregular manner in all directions (figs. 1 and 2), so that there can be no question of any regular tentacular corona. The number of these tentacles, which, as above mentioned, are attached in a double row along the anterior side of the tentacular arms, is somewhat various (about forty on each arm); they are longest about in the middle, and are in this part about one third of the length of the arm, and diminish somewhat towards the base, but more towards the extremity, where they are often quite rudimentary. The *tentacular arms* themselves, each of which, at the base on the dorsal side, is furnished with a little fascicle of unusually long cilia attached to a small tubercular prominence (figs. 1 and 3, n), are of very considerable length—quite as long as the whole of the rest of the body—of narrow cylindrical form, thickest at the base, and tapering regularly to the end, which is obtusely pointed. Anteriorly they are separated (see fig. 4) by a naked, somewhat concave part (extending a little downwards), here contiguous to the basis of the remarkable oval shield (c), which, both by its enormous development and peculiar function, below described, forms one of the most peculiar features of the *Rhabdopleura*.

Between the bases of the tentacular arms, and from a somewhat ventral point, proceeds in an anterior direction a large and very remarkable prominence, situated longitudinally, which has the form of an oblong thick disc or shield, one surface of which (the dorsal surface) is in the middle grown together with the anterior end of the body, while the ventral surface is free and bordered by a rather thicker raised ridge, distinct from the adjacent parts. The

form of this disc is, as above mentioned, oval, or rather, rounded pentagonal (see fig. 2, c), nearly half as long again as wide, the width about equal to that of the body at the beginning of the stomach. Its posterior border, which at once shows itself separated by a deep constriction from the part of the body lying behind it, is in the middle slightly incurved (fig. 3). The side borders are, a little in front of the middle, strongly, almost angularly bent, and then converge strongly towards the anterior freely projecting extremity, which is narrowed obtusely. The whole disc is everywhere, and especially distinctly on the edges, thickly covered with small vibratory cilia. Allman, who also mentions this prominence, but without having gained a correct notion of its form and connexion with the other parts, says of it that one might take it for a large and peculiarly developed epistome, if its position on the ventral side of the mouth, and not, as in the freshwater Polyzoa, between the mouth and the anus, did not oppose such a supposition. Allman supposes, thus, that the mouth in the *Rhabdopleura*, in analogy with the other Polyzoa, is terminal, and situated above or on the dorsal side of this prominence, between it and the anus. Such is, however, not the case. The anterior extremity of the body above the prominence described is completely closed, without any trace of aperture (see fig. 4). On the other hand I have, by gently compressing the animal, been able distinctly to see (see fig. 1) that the buccal aperture (q) is situated just on the ventral or hæmal side behind that prominence, and seems to have the form of a cross slit, which is bordered behind by an oval lobe (m), furnished with vibratory cilia like a sort of underlip. By increased pressure the buccal shield could be moved more out from the base of the tentacular arms, and it appeared then everywhere very distinctly constricted from the rest of the body, and in the middle of the dorsal surface fixed to the body by a sort of short stalk, while the upper and the lower parts were free. Further, it was observed that on each side of the buccal shield there extended, from the base of the tentacular arms downwards, a strongly projecting nearly semilunar border of thin skin (l), ciliated on its edges, so that between this and the buccal shield there is formed on each side a narrow half-tube or channel leading to the buccal aperture, and through which the nourishment is probably conveyed to the mouth by the abundantly ciliated tentacles. Since, as above stated, the said buccal shield is really situated between the mouth and the anus, I think we may consider it as morphologically answering to the so-called epistome in the fresh water

Polyzoa. Its enormous development in the present instance seems, however, to indicate that it must have a very peculiar and important function in the economy of this animal. My observations on the living animal have also guided me to a decided opinion, to which, however strange it may appear, I have been forced again and again to return, and which I therefore must retain, namely, that the animal uses this buccal shield (according to my observations) as *a sort of creeping organ, by means of which it can draw itself up to the aperture of its tube.* Since, as above stated, both endocyst and all muscles of protrusion are wanting, it is in reality quite inexplicable how the polypide, which is often found drawn back, not only to the bottom of the free cell, but even partially into the corresponding chamber of the creeping stem (see fig. 6), should be able in any other manner to get forward again so far as to the aperture of the cell. It might, perhaps, be supposed that this could be effected by means of the elasticity of the contractile cord; but I have convinced myself that such is not the case, by cutting through the contractile cord at its base; the polypide has continued undisturbed its slow protrusion, and has also at length really reached the opening of the cell without any remarkable change. The direct observations made on the uninjured animal have also confirmed me in the view expressed above. It will be seen that during the slow protrusion of the polypide (which often lasts for hours) the buccal shield is always in immediate contact with the wall of the tube, the whole of its ventral side being closely pressed up against the same; it retains this position unchanged as long as the protrusion lasts; and the protrusion does not stop until the whole length of the buccal shield is extended outside of the aperture of the cell; then the Polypide is completely expanded. On examining more closely this buccal shield we observe in the middle of it an opaque part, which seems to contain an interior glandular organ. Continuing the investigation, and slightly pressing the animal, we notice, however (fig. 2), that this opaque appearance is not produced by any such internal organ, but by a peculiar and seemingly muscular structure of the substance of the shield itself. It exhibits, seen from below, in the middle numerous small bubbles, situated rather far from each other, or somewhat irregularly formed small cells, which, however, when more closely examined (and this is particularly evident in those which lie nearer to the periphery of the disc), show themselves to be the external rounded extremities of small, inwardly prolonged cylinders, which

together appear to form a thick fascicle of incompletely differenced muscular fibres, penetrating into the stalk of the buccal shield.

The animal is, with the aforesaid exception of the stomach and the intestine, which are opaque yellow, colourless and transparent. The tentacular arms, and the tentacles, as also the anterior part of the body before the stomach, are covered with numerous very small, irregularly shaped, intensely dark violet spots of colouring matter, which also occur on the buccal shield, and especially on its anterior freely projecting extremity, where they are very close together, forming a large, roundish, dark spot. In specimens in spirits all these parts are dark reddish brown, which probably arises from the diffusion of the dark colouring matter produced by the spirit.

As above stated, the polypide is without any sort of attachment to the cell, in which it lies quite free. But it is attached by means of a long and thin fleshy cord to the axial cord, which runs through the creeping part of the Polyzoarium or stem. The attachment does not take place immediately at the bottom of the free cell, but at the bottom of the corresponding chamber of the creeping stem, close to the transversal septum which divides the chamber from the next preceding. This cord, issuing from the body of the polypide (figs. 5, 6, &c., h), is of very considerable length; as, when the polypide is expanded, it extends not only through the whole length of the cell, but also through the corresponding chamber of the stem. The cord is, however, very thin, filiform, when fully extended five or six times less than the calibre of the cell, and four times thinner than the stomach. It is of cylindrical form, and lies quite free, without being attached at any point to the wall of the cell; but it is nearer to the one side (the ventral) than to the other. Along all one (the dorsal) side it is covered with the same sort of small, dark violet spots of colouring matter as the anterior part of the body, the tentacular arms, &c., but is otherwise quite colourless and transparent, and is of a soft fleshy consistency. It shows on closer inspection, in a part of its substance, an extremely fine fibrous structure of fine parallel, longitudinal lines and less sharply marked transverse lines; but in the dorsal part these fibres are entirely wanting, and the structure of this part seems to be cellular, and its edge appears somewhat irregularly wavy. With regard to its attachment to the polypide, this does not take place at the bottom of the stomach, but rather high up on the ventral side, where it

seems to go over into the thin skin which encloses the digestive apparatus. Its ventral fibrous part may still be traced (see fig. 1) to a considerable distance forward, in the form of a rather wide, clear skin border, which gradually disappears in front of the cardia. In this skin border the fine longitudinal fibres may still be distinctly observed diverging like radii; but I was not able to trace their course further. The posterior end, which, as beforesaid, is attached to the axial cord at the bottom of the chamber in the stem which corresponds to the cell, is somewhat enlarged; and all through of a very distinctly marked cellular structure, without any evident fibre. In spirit specimens the contractile cord shows itself often irregularly thickened in particular places, and is also thus represented in Allman's figures; but this appears to be only a result of the action of the spirit. In living exemplars I have always found it, whether fully extended or contracted, of a cylindrical form. When the polypide, as is frequently the case, is very strongly retracted, not only to the bottom of the free cell, but also partly in the corresponding chamber of the stem, the contractile cord is always spirally convolved, so that the coils are closer or looser, accordingly as the retraction is stronger or weaker (see fig. 6). Also when, after severing the contractile cord at its base, we take the animal out of its cell, the cord always convolves itself in spiral coils.

Allman has considered this contractile cord as corresponding with the so-called funiculus in the ordinary Polyzoa, although it is not, as in these, attached to the end of the stomach (the terminal cæcum), but on the ventral side of the polypide's body (Allman has represented it erroneously as attached near the end, on the dorsal side). Moreover, Allman indicates that this funiculus is accompanied by a long fascicle of muscular fibres, attached to the chitinous cord (axial cord) at the point where the funiculus is joined to the same; and that at the point where the funiculus is joined to the animal's body, this muscular fascicle divides itself in two bands, of which one goes along the right side, and the other along the left side of the body, finally attaching themselves, each on its own side, to the pharynx below the lophophore. These fibres form, according to Allman, the great retractor muscles of the polypide. This representation, which in fact only depends on spirit specimens, does not, as may be seen, agree with what I have had occasion to observe in our northern species, in which the fascicle of muscles (if one really may venture to use this appellation here) is everywhere, as an integral part, intimately con-

nected with the contractile cord, and is produced only by a peculiar modification of its tissue on the ventral side. Special retractor muscles cannot, therefore, any more than other muscles, be said to be distinguished in the *Rhabdopleura*.

Through all the creeping stem there extends, as already mentioned, a filiform cord, very remarkable by its dark, nearly black colour, and, unlike the contractile cord, to which it is about equal in thickness, only slightly flexible, and of a very hard, chitine-like consistency. This cord (figs. 5, 6, &c., i), which we will call the axial cord ("chitinous rod," Allman), is freely extended in the hollow of the individual chambers into which the stem is divided, and only attached to the septa, which it perforates, enlarging itself a little. In conformity with the rarely branched form of the stem, it is only now and then forked, and when this takes place, it is always at one of the septa. Otherwise, it forms everywhere a cylindrical tube with very strong, almost horny, walls, but always enclosing in its interior a soft, cellular cord (s), of similar appearance to the contractile cord, and, like it, colourless and transparent, with small dark violet spots of colouring matter, but scarcely half so thick. This fine cellular marrow, which extends through the whole length of the axial cord, seems entitled to be considered as a sort of incompletely defined nervous trunk, connecting all the individuals of the colony, as at each partition in the stem it sends forth a branch, which enters into the contractile cord of each respective individual animal; and the latter cord does also probably contain in its dorsal part the imperfectly developed elements of nerves. We may, therefore, herein observe the analogue of the so-called colonial nervous system (so strongly developed in the other marine Polyzoa), and specially in the marrow of the axial cord, the common main trunk of the whole colony.

Allman, who has drawn special attention to this peculiar chitinous axial cord (which does not exist in any of the known Polyzoa), and has precisely derived from it his generic appellation, calls it a "blastophore," being of opinion that it is destined to bear the so-called statoblasts, which he represents as projecting from the posterior part of the contractile cord. I regret that I cannot, from my own experience, give any decided opinion as to the axial cord having likewise this destination, because I have not been able to observe the formation of these so-called statoblasts.

The animal, unlike the other Polyzoa, is very slightly sensitive, and is not much affected by having its tentacles or body touched. If the irritation is strong, it draws itself,

but only very slowly, and usually only a little way, back into its tube. This very slow and sluggish *retraction,* which may last a very long time before it ceases, contrasts strongly with the extraordinary, almost lightning-like, rapidity with which the retraction takes place in the other Polyzoa, and is evidently accounted for by the want of special retractor muscles, and by the slightly developed contractile elements, not distinguishable as evident muscular fibres, in the contractile cord, the only instrument by which the retraction of the animal in the *Rhabdopleura* is effected.

The extension (protrusion) of the animal is yet far more tardy than the retraction; the process is extremely slow and almost imperceptible; several hours may often elapse before the animal progresses from the stem or bottom of the cell to the aperture of the latter. Neither do we, as before remarked, find in the animal under consideration the slightest trace of any special muscles for such progression, since the endocyst, and also the parietal and parieto-vaginal muscles connected with it, are entirely wanting. The protrusion seems, on the other hand, as already mentioned, to take place in a very peculiar, and in the highest degree remarkable, manner, that is, solely by means of the enormously developed epistome (buccal shield) which the animal uses, strange as this may sound, as a sort of *creeping organ,* like the foot, or creeping disc of the Gasteropods, to draw itself upwards, little by little, along the wall of the cell to the aperture.

The *Rhabdopleura mirabilis* seems to be a genuine deep-sea product, which I have never found at a less depth than 100 fathoms; but it is probably to be found extensively at greater depths, where it appears to be more and more plentiful. I have hitherto only found it in Lofoten, where it is not uncommon, in soft clay bottom, at depths of 100 to 300 fathoms. As the polyzoarium is both very small and entirely colourless, it is rather difficult to discover. Its presence is, however, easily detected by stirring the washed mud in a fine sieve with a feather or other instrument, when irregular fibres will be noticed therein. These fibres, covered with particles of mud, Rhizopod-shells, and fragments of mussel shells, will prove to be the creeping stem, whereon, by closer investigation, there will be discovered the small, transparent, perpendicularly projecting cells. One seldom, however, succeeds in raising these colonies entire; they are most frequently broken into several pieces by the dredging operation itself, or in washing out the mud.

We may, according to the preceding description, characterise the Genus *Rhabdopleura* in the following manner:

Gen. Rhabdopleura, *Allman.*

Polyzoarium tubum formans tenuem, flexibilem, cylindricum, chitinosum hyalinum ex stirpe compositum repente intus septis transversis in cameras plures discretas divisa quarum utraque in cellulam cylindricam plus minusve liberam et erectam stirpe vix angustiorem subtiliter annulatam vel plicis acutis circularibus dense ornatam, orificio simplice circulari terminatam exit. Stirps in tota longitudine *chorda chitinosa,* obscura, tenui, cylindrica, rigida, pulpa vero molli cellulosa impleta trajecta.

Polypides nullo endocysto vel pallio parietibus cellularum connexi, sed modo *funiculo contractili* tenui et carnoso chordæ stirpis chitinosæ affixi, corpore forma elongato-ovata, extremitate anteriore paulo dilatata et in ramos divisa duos cylindricos et attenuatos supra vergentes et a se divergentes, quibus series duplex tentaculorum flexuosorum affixa est. Series tentaculorum minime continua sed et supra et infra intervallo distincto interrupta, quare nulla adest corona tentaculorum vel lophophorus proprie dictu sed modo *duo rami tentaculiferi valde flexibles.* Inter bases horum ramorum inferne adest prominentia magna carnosa scutiformis ovalis vel subpentagonalis pedicello brevi et crasso affixa facie inferiore subplana extremitate antica libere prominente attenuato-truncata, inferiore corpori incumbente medio leviter emarginato superficie ubique dense ciliata.

Orificium oris subventrale, transversum pone prominentiam scutiformem situm, postice rotundato ciliato limitatum· *Œsophagus* brevis et spatiosus constrictione distincta a ventriculo sejunctus; *ventriculus* simplex subteres, postice attenuatus et sine fine, ansam subitam formans in intestinum transiens; *intestinum* antice porrectum tenue cylindricum lateri dorsali ventriculi et œsophagi incumbens; *orificio anali* circulari ad basin ramorum tentaculiferorum supine sito. Tractus intestinalis, vel corpus proprium polypidis minime nudus, sed cuticula distincta, tenui, hyalina circumcirca arcte circumdatus.

Musculi adsunt *nulli* distincti, neque retractores, neque protractores. Retractio Polypidis solummodo funiculo contractili effecta; *protrusio* singulari modo prominentia effici videtur scutiformi præorali, at modum soleæ gasteropodum. Et retractio et protrusio polypidis segnissima.

Spec. *Rhabdopleura mirabilis* (M. Sars).

Polyzoarium irregulariter flexuosum sed raro modo et parce ramosum, stirpe corporibus alienis modo ex parte ad-

hærente ubique particulis alienis vel quisquiliis dense obducta, cellulis vero nudis in tota longitudine liberis perpendiculariter ascendentibus, vario modo flexuosis, valde elongatis (15^{ies}—16^{ies} circiter longioribus quam latioribus) stirpe vix angustioribus.

Habitat ad insulas Lofotenses in profunditate 100—300 orgyarum fundo limoso, non infrequens.

I have unfortunately not been able to make any observations on the development of the living animal, in which I have also in vain sought for the organs of generation. It was only by critically passing in review the specimens, which I had brought home one by one, that my father at last succeeded in discovering in the creeping stem a couple of polypides in course of formation. Allman has, however, been more successful, and has even found in the specimen of the *Rh. Normanni* examined by him, a whole series of developments, which is of great interest. I can, therefore, only add very little to Allman's communications on this subject. Both of the buds observed by me had their place in separate everywhere closed chambers of the creeping stem, without these chambers having as yet prolonged themselves into any cell, and, like the developed polypides, appeared here attached to the axial cord near the bottom of the chambers, at a short distance from the transversal septum. The youngest of the buds (fig. 7) corresponds approximately with the youngest stadium observed by Allman, as only two parts were to be distinguished, a short stalk and an enlarged terminal part, which had not however, the form indicated by Allman, of two compressed valvules, but of a wide, scutiform, slightly curved plate (see fig. 7). The stalk (h), which is strongly, almost globularly enlarged, is continued for some distance along the concave side of the scutiform plate mentioned; but this continuation, which is not visible from one (the ventral) side, is by an evident instriction separated from the proper stalk, and represents the groundwork of the polypide's real body, whence as well the tentacular arms as the digestive system are afterwards developed. The other bud (figs. 7, 8, and 9) will about answer to the stadium delineated by Allman, l. c., fig. 6. The peculiar scutiform part (c) has also here the form of a wide, evenly curved plate, which already has assumed a somewhat pentagonal form, and completely covers on one side the still only slightly developed real body, from which, however, there project in front, two tentacular processes (d, d), extending beyond the border of the shield, and

slightly crenulated at the edges, representing the tentacular arms; the stalk (h), which represents the contractile cord, has lengthened itself considerably (see fig. 9), and its anterior part forms a strong enlargement, marked with evident traces of the spots of dark violet colouring-matter peculiar to the adult animal. The real body was, as stated, still very slightly developed, and appeared only as a small rounded part projecting dorsally between that enlarged part of the stalk and the basis of the tentacular arms; on the ventral side, or that which turned towards the concave surface of the scutiform plate, it was in the middle, and to a small extent united to the same by growth; and behind this union there appeared already an evident incurvation or incision in the body of the polypide as the first indication of the buccal orifice. That the large scutiform plate is the homologon of the buccal shield in the fully developed polypide is sufficiently evident, both from its position relatively to the animal's body and from its shape. Allman has also recognised this; however, when he assimilates this plate in the Rhabdopleura-buds with the mantle lobes of the Lamellibranchiata, the notion seems to me very hazardous and difficult to establish. In any case, the early appearance and enormous development of this part in the buds of the Rhabdopleura are extremely remarkable.

Allman has—guided especially by the mode of development in the *Rhabdopleura*—come to the conclusion that the Polyzoa are not, as was formerly imagined, most nearly related to the Brachiopods, but to the Lamellibranchiata, and gives, l. c., some schematic figures, in order to represent more evidently the agreement of the Rhabdopleura-buds with a Lamellibranch. Allman, however, presupposes, as taken for granted, that the *Rhabdopleura* is furnished with an endocyst of the same nature as the other Polyzoa, which, as above stated, is not the case, as also his conception of the buccal shield seems to be inaccurate.

As will be seen in the sequel, my father has acquired a very different notion with regard to the relationship of the Polyzoa; for—guided by the organization of their lowest representative, the *Rhabdopleura*—he has arrived at the surprising conclusion that the Polyzoa in all probability have taken their orgin from the Cœlenterates, namely, the Hydrozoa.

Like Allman, I sometimes found in the middle of the stem of the polyzoarium individual chambers, which, without containing any bud in process of formation, were quite closed and not continued into any cell. The interior

wall of these chambers was always of very dark horn-brown colour, and so little transparent that the axial cord, also here running in the middle, was but dimly discernible through the wall. This dark colour was particularly intense at one of the ends, and appeared to proceed from the axial cord fixed in the middle of the septa, and here somewhat enlarged. Its exterior horny substance seemed to be directly continued into the adjacent chamber of the stem. Allman considers these closed chambers, wherein he has thought to perceive a stratum of large polygonal cells—of which, however, I have not been able to observe the slightest trace in any that I have examined—as statoblasts, and thinks that they are formed by the posterior enlarged part of the contractile cord. This seems to me, however, to be far from probable, at least in reference to the closed chambers examined by me; for they looked far more like remains of old cells decayed, owing to the destruction of the Polypide, as is found to be the case with other Polyzoa in the oldest part of the polyzoarium.

It will be seen from the foregoing description that the genus *Rhabdopleura* differs in nearly all essential points from the ordinary Polyzoa far more than Allman seems to have conceived. If we compare what is here communicated with the chief points which have been briefly enumerated by various authors, for instance, Allman, Hyatt, &c., others, as characteristics of the Polyzoa in general, and which, therefore, are considered as essential marks most intimately connected with the idea Polyzoa, the anomaly of this form becomes so striking as finally even to justify a doubt as to whether it really can be referred to the class of Polyzoa. First and foremost stands *the want of a so-called endocyst or mantle*, which sharply distinguishes this form from all other known Polyzoa, all of which possess such an appendage. This mantle is so essential a component part of a Polyzoon that it is difficult to imagine one without it. One would rather imagine the ectocyst wanting, as this plays a far less important part in the economy of the animal, generally remaining passive, and properly only serving as a protection for the soft animal. The mantle is likewise a characteristic for the Tunicates and the Brachiopods, which two classes have also been united by M. Edwards with the class Polyzoa, under the common appellation of Molluscoidea (Häckel's Himatega or Mantle-animals).

Next, and as a consequence of the absence of a real endocyst, the retraction and protrusion of the animal in the *Rhabdopleura* are effected in a manner totally different from that

of the genuine Polyzoa; it moves up and down in its cell without being attached to the opening, *not by invagination and evagination* of the anterior part of the cell, and *not by several sets of special separate muscles.*

The following remarks on the affinity of *Rhabdopleura* are from my father's manuscript notes:

The *Rhabdopleura* shows in many respect an unmistakable resemblance to *certain Hydrozoa.* Just as in these, the individual animals are not attached to the anterior part of the cells (in the Polyzoa the anterior involved part of the endocyst is attached all round to the basis of the tentacular corona); the cells are therefore open, filled (not with the so-called perigastric liquid, but) with the sea-water entering from without, and the aperture of the cell is of a defined and invariable shape (while the cells of the Polyzoa are always closed by the attachment of the endocyst to the basis of the tentacular corona, and have, therefore, no proper opening, for what is called aperture is nothing more than the part of the cell through which the animal passes in an and out)."

"Moreover, the *retraction* of the animal, effected in the *Rhabdopleura* by means of *the contractile cord,* at the end of which the animal is suspended, coincides essentially with that of the Hydrozoa, in which the part corresponding to that cord ('the fleshy stalk or axis,' 'the intestinal canal' (Lovèn), 'the branched or unbranched cœnenchym, on which the individual animals are situated, and which is perforated by a canal-like continuation of the abdominal cavity of the individual animals') is, indeed, usually less free (often in many places attached to the wall of the cell), and possesses a less degree of contractility than the *Rhabdopleura,* but yet, in some genera, f. ex. *Grammaria,* also nearly approaches the *Rhabdopleura* in these respects. On the contrary, the *protrusion* in the *Rhabdopleura* is effected in a peculiar manner, and different from that of either Polyzoa or Hydrozoa, namely by a sort of *creeping,* executed by the preoral prominence (buccal shield), which appears to answer to the epistome in the other Polyzoa, although in these it must have an entirely different function."

On the other hand, *the highly developed digestive system, the presence of an anus, the juxtaposition of the mouth and anus,* and, finally, the bilateral *lophophore,* are all characters peculiar to the Polyzoa, and entirely foreign to the Hydrozoa.

It is clear that we have under observation in the *Rhabdopleura,* a form of animal life which stands as it were in the middle between the Hydrozoa and Polyzoa, or forms a transition from one to the other; one of those "perplexing

forms" which will not fit rightly anywhere in the system of zoologists.

When, finally, and as the object of the whole investigation, we will give account of our conception of the *Rhabdopleura,* and decide on the class to which we will refer it, our opinion is that these questions, like so many others, can only be properly answered through the medium of the Darwinian theory.

The *Rhabdopleura* is, undoubtedly, like many other animals which at present inhabit the greater depths of the sea, and with some of which we have in the latter times become acquainted, *a very old form,* which in its organisation has still retained several features from the time when the animal type that we call Polyzoa first developed itself from a lower type.

The Polyzoa, which most authers agree in referring to the main type or trunk (phylon) of the Molluscs are usually supposed among the other animal types, to show the greatest affinity with the *Vermes ;* and they are even considerod by many zoologists as not being molluscs at all, but as genuine worms. Their affinity to worms has, however, not been demonstrated by any evident and distinct transition-form between the two are not known. The *Rhabdopleura* shows how evidently that the Polyzoa are *not* most closely related to the *worm*-type, but in the type of the *Cœlenterates,* and especially to the class of *Hydrozoa.* The Polyzoa have already in the earliest primordial times (for fossil remains of them are found in the lowest silurian formations) developed themselves from the Hydrozoa by transmutation. We have in the *Rhabdopleura* manifestly such a form of Polyzoa in course of development out of a form of Hydrozoa. The changes which must take place in order that a Hydrozoon can be transmuted into a Polyzoon consists in the following points. Instead of the simple abdominal cavity of the Hydrozoa, with a single aperture which functions as both mouth and anus, there is formed *an intestinal canal with special walls,* dividing itself into three sections—gullet, stomach, and intestine, which last ascends alongside of the stomach and gullet, terminating with an exterior aperture or anus in the vicinity of the mouth. This formation is completed in the *Rhabdopleura,* but no more. The following phases of this development which consist in the formation of a wide sack-like contractile *endocyst or mantle,* which in its anterior part is detached from the ectocyst or cell, involved in itself (invagination) and attached round about the basis of the tentacular sheath, vaginal, whereby the animal that formerly was free in

in its cell now becomes attached to the anterior part of the cell, and *the complicated system of the special retractor and protractor muscle*, all the mutations have not yet taken place in the *Rhabdopleura*. This animal has thus remained stationary in the first stage of development from a Hydrozoon to a Polyzoon, but must, nevertheless, be considered as belonging to the type (trunk) of the Polyzoa, since the development of the completely organised digestive system, which is so entirely foreign to the Hydrozoa, sufficiently stamps it as a Polyzoon.

Finally, we remark that it may appear strange that the *Rhabdopleura*, which in all probability is of so ancient origin, should possess a similar, although modified, form of tentacular Corona (bilateral) to that which belongs to most fresh water Polyzoon (*P. Hippocrepia*, Gervais, Phylactolæmata, Allman), and which is usually considered as a more perfect formation that the circular (in *P. infundibulata*, G.). It is, however, possible, that the first is properly the circular form, from which the latter has subsequently arisen. The fresh waters appear, as Hæckel lately has remarked, to contain the direct descendants of some of the eldest animal forms which, by reason of the less complicated accident of the fresh waters, have often in the "struggle for life," only slightly altered their original more simple structure; as for instance, among the Cœlenterates, the *Hydra*; among the Rhizopods, the *Actinophrys*, *Gromia*, and the shell-less Radiolaria lately discovered by Focke; among the fish, the Ganoidea, &c.

On the Existence *of an* Enamel Organ *in an* Armadillo (*Tatusia Peba*). By Charles S. Tomes, M.A. (With Plate II.)

According to the views of Arnold and Goodsir, which for many years have passed current amongst anatomists as being a correct interpretation of the early stages of tooth development, the dental germs first make their appearance as free uncovered papillæ, rising up from the bottom of an open groove, to which was applied the name "primitive dental groove;" and our anatomical text-books have hardly kept pace with advancing knowledge in this matter, for even in some of the most recent these views of Arnold and Goodsir, now in some important particulars obsolete, are to be found.

With the subsequent stages in the development of the teeth we are not for the present concerned; the prominent feature of Arnold and Goodsir's view, which was long adopted by almost every writer, was the appearance, in the first place, of a free, *uncovered* papilla, which was afterwards destined to be calcified into dentine.

As expressing the matter clearly and concisely, I may quote the words of Professor Owen:[1]

"In the development of a tooth a matrix or formative organ, corresponding in complexity with the kind of tooth to be formed, is first developed. It consists either of a soft vascular papilla—*a free conical process*—as in certain fishes, which mould of the future simple tooth is called its 'pulp,' or 'the dentinal pulp,' or it consists of the pulp enclosed in a 'capsule,' or of a *pulp with such a modification of its peripheral part,* situated between the pulp proper and the capsule, as to merit a distinct definition as an 'enamel organ.' The *first* and *most constant* of these parts is termed the '*dentinal pulp*,' the second is the capsule or 'cemental pulp,' and the third is the 'enamel pulp.'"

To this I may add that the simplest teeth consist only of dentine, the next stage in complexity being the addition of cementum, while the presence of enamel marks a third stage in complexity; so that it would be quite in accordance with the little that we know of the laws of development that in an animal whose teeth ultimately possess all three structures the dentine germ should appear first, next that of the cementum, and lastly that of the enamel; it would, in fact, then be an illustration of "progress from the general to the special in development."

But unfortunately more accurate observations do not confirm this. The order of appearance of the three several germs is not by any means that above described, and the researches of Professors Kölliker and Emil Dursy have shown (1) that there is never at any time a deep, widely open groove, from the bottom of which spring up free, uncovered papillæ, but that the "primitive dental groove," as seen and described by Arnold and Goodsir, was "artefact;" and (2) that at a period when the dentine germ has no histological characters, but is only distinguishable from the surrounding tissue as a slight opacity of no very definite form nor definite limits, the enamel germ has undergone active growth and very manifest histological differentiation of its component cells (see fig. 2).

Thus, although a skilled observer can detect faint indica-

[1] Article "Odontology," 'Encyclopædia Britannica,' p. 414. The talics are my own.

tions of the future dentine germ, the first thing of which he can be positive is the enamel germ, which at this early period is far in advance of the other component parts of the tooth in respect of its development. In thinking over the increased importance from a homological point of view, which is given to the enamel organ by its very early appearance and its entire independence of the dentine and cemental germ in its origin, it occurred to me that it would be exceedingly interesting and instructive, to examine the tooth germ of a mammal whose teeth are not coated with enamel; and I hasten to acknowledge the kindness of Professor Agassiz in America, of Professors Rolleston and Westwood at Oxford, and of Professor Flower at the Royal College of Surgeons, for placing all the material which they possessed at my disposal.

The difficulty of the inquiry was very greatly enhanced by the condition of the specimens, which had all been kept in methylated spirit of varying strength, and it was extremely troublesome to make sufficiently thin sections, as the tissues were very friable. The best results were obtained by placing them in absolute alcohol, whence they were transferred to strong glycerine, and then imbedded and cut in the usual way.

In order to make my description more intelligible I have placed side by side with the figures of the dental germs of the armadillos a drawing of a section through the lower jaw of a calf (fig. 1), to some few points in which I will draw attention before comparing and contrasting them with one another.

The enamel organ (*c*) in this figure forms a cap, embracing the upper part and sides of the dentine germ (*b*); it is seen to be still connected with the epithelium (deep layer) of the mouth by a thin dark line, which, under favorable conditions of lighting, &c., may be seen to consist of a double row of cells. Where this merges into the enamel organ these two rows of cells separate and pass round the periphery of the enamel organ, forming what is known as the "external epithelium of the enamel organ;" near to the base of the dentine germ this layer of epithelium is reflected upon it, and forms a complete investment to its surface, in which situation it is termed the "internal epithelium of the enamel organ."

But in the calf these external and internal epithelia are widely separated and form but a small proportion of the whole bulk of the enamel organ, the intermediate space being occupied during the formation of the enamel by a stellate

reticulum, which seen by the naked eye looks almost semi-fluid or gelatinous. When the deposition of enamel is completed this gelatinous mass disappears and the external comes into contact with the internal epithelium; a fact of some interest in connection with the dental germs of the armadillo.

From the line of cells which connect the enamel organ with the deep layer of the oral epithelium (by an inflection of which it was originally formed) runs downwards a process consisting of a double row of cells, not unlike a simple tubular gland; this has been shown by Professor Kölliker to be the enamel germ of the permanent tooth.

The earliest condition of dental germ which I have observed in the armadillo is represented in fig. 2; the section was taken from a fœtus about an inch long. At *c* is seen the enamel germ, consisting of a mass of cells, those upon its surface being distinctly differentiated from those in its interior, and forming a sort of epithelial investment to it; it is connected with the epithelium of the oral cavity by the usual thin neck of cells, and it is similar to, and in fact perfectly indistinguishable from, the enamel germs of those other mammals which do have enamel upon their perfected teeth.

The future dentine germ and its processes forming the capsule are as yet only represented by a slight opacity, which has been rather exaggerated in the drawing.

The next stage which I have observed is represented in figs. 3 and 4; the dentine papilla (*b*) has taken a definite form; the cells on its exterior have become differentiated to form an odontoblast layer, and towards the top a thin cap of dentine (*h*) has already been formed.

Closely applied to the formed dentine, and extending below it on the surface of the dentine germ, is an investment of columnar cells, exactly like the internal epithelium of the enamel organ (enamel cells) of other mammals, and at first sight this might appear to be all that there is. But in specimens which have been slightly displaced or torn, the epithelium is seen to really consist of two layers, one of which adheres closely to the dentine, and the other to the capsule; and towards the base of the dentine germ, where the epithelial layer is reflected over it, it can always be seen to be double (see *g*, figs. 3 and 4). In fact this apparently single layer is really made up of the internal and external epithelia in close contact with one another, owing to the absence of that reticulate tissue which separates them in the enamel organ of those animals which form enamel on their teeth. And this is just what has already been noted to be the condition of all enamel organs after the completion of the enamel.

Although I have examined six or seven specimens, I have not been successful in getting satisfactory sections illustrating any other stage in the tooth-development.

I have, however, examined a large number of the teeth of armadillos, removed from the tooth sacs prior to their eruption, and have not discovered the least vestige of enamel upon any of them; the cementum covers them nearly to the tip, but I have never seen it quite reach to the tip of the tooth.

The results of my inquiries may be summarised thus:

1. In *Tatusia Peba*, a creature which has no vestige of enamel upon its teeth, the first histological structure distinctly recognisable in the tooth germ is a well-developed enamel germ, perfectly identical with that seen in other mammalian fœtuses of similar age.

2. That, without any enamel having been formed, and at a very early period in tooth development (namely, contemporaneously with the formation of a very thin cap of dentine), this enamel organ assumes a condition precisely similar to that attained to by other enamel organs after their function has been completed by the deposition of the whole thickness of the enamel.

The persistent connection of the enamel with the oral epithelium from which it was derived is very well shown by many of the sections, some of which also show well the second inflection of epithelium which forms the enamel germ of the permanent tooth, thus affording an additional confirmation of the fact, to which attention has been drawn by Rapp, Gervais, and Professor Flower, that amongst armadillos *Tatusia Peba* at all events is not a monophyodont, but possesses two well-developed and functional sets of teeth.

The occurrence of a structure which is destined to be made no use of in the further course of development would of itself be noteworthy, but this observation on the teeth of the armadillo possesses a wider interest, for it bears on the whole question of the affinities and genealogy of that peculiar group, the Edentata; it would, however, be out of place to enter into a discussion of its probable significance in the pages of a journal specially devoted to Histology; and, moreover, our knowledge of the development of the teeth of the mammalia being limited to those of a very few species, it would be unsafe to enter upon generalisations built upon so imperfect a basis.

Researches *on the* Mucorini, *by* Ph. Van Tieghem *and* G. Le Monnier (with Plates III and IV).[1]

Since modern research has demonstrated the existence of polymorphism in the reproductive organs of Fungi, there has been a general agreement as to the necessity of a revision of the entire class. No species of fungus can now be said to be thoroughly understood until all the reproductive structures have been discovered which its mycelium is capable of developing as well as the order in which they succeed one another, or alternate. From being acquainted with but one kind of reproductive apparatus we may easily fall into error in assigning to the species to which it belongs a wrong place in a natural classification. Such a determination must be necessarily provisional, and it is most essential to endeavour to arrive at a knowledge of those other reproductive states which can alone enable us to certainly determine its true systematic position. It may even happen that two species belonging to distinct genera may each have a reproductive apparatus (and this may also happen to be at the time the only one known) which may have so close a resemblance as to all but justify us in regarding them as identical. The number and nature of the reproductive structures which a species posseses cannot be deduced *à priori* from any general law; in different families of the same class the vegetative cycle may embrace an altogether different series.

It is evident, therefore, that the study of fungi presents great difficulties which explain the slowness as well as the uncertainty of its progress, and even the retrograde direction it has taken and the confusion into which it has fallen in the hand of some authors. These difficulties are of two kinds, synthetic as well as analytic. The first present themselves when we attempt to correlate with the species to which it belongs some reproductive structure which we meet with altogether isolated. The others arise when we seek to distinguish amongst the numerous forms which habitually grow mixed together those which have a true genetic

[1] [This article is a free but condensed translation of portions of a memoir occupying nearly 140 pages of the 17th volume (pp. 261—399) of the current series of the 'Annales des Sciences Naturelles.' The extremely interesting results arrived at by the authors derive a special importance from the precision of the method which they have devised and employed. It is much to be hoped that this will attract the attention of microscopists in this country, and lead to the repetition and extension of similar observations.—W. T. T. D.]

connection; it is necessary to carefully discriminate cases of epiphytism or parasitism from true polymorphism.

In order to attain this complete knowledge of any given species derived from the observation of the whole cycle of its development, and to avoid the two kinds of difficulties just mentioned, there is obviously only one method. In principle this is extremely simple; it is necessary to proceed exactly as in dealing with one of the higher plants. We sow a seed and follow the complete vegetative and reproductive development of the plant which is derived from it until the production of new seeds brings us back to the point from which we started. In the present case we must sow a spore and follow without any interruption, and excluding all extraneous organisms, the vegetative and reproductive evolution of the plants which originate from it until we have exhausted the whole series of reproductive forms which the vegetative system of the plant is capable of originating in the different media in which it may be necessary to study it in order to obtain the whole of them.

The method which we have followed for carrying out practically this principle so simple in theory—the culture of a single spore—includes two distinct parts, which may be termed respectively ‘pan-culture’ and ‘cell-culture.’

In pan-culture the nutritive medium, previously, if necessary, freed from extraneous living germs, is placed in saucers or pans of porcelain or some porous material, and enclosed under a bell-jar or covered with a glass plate. The nutriment being abundant, the vegetative system acquires extreme vigour, and the fructification attains its most complete development. Specimens can, therefore, be obtained at regular intervals of time, which enable one to judge of the principal characters of the mycelium and its mode of growth, and to study the different stages of development and the structure and dimensions of the different forms of fructification which it bears under the most favorable possible conditions. The pan-culture, in addition to this, supplies us with spores for the cell-culture.

By cell-culture we mean a method in which a spore taken from an unmixed pan-culture is placed, with all necessary precautions, in a drop of liquid accessible in every part to microscopic observation, and known to be free previously from other spores, and which, being enclosed in a cell, is preserved from subsequent contamination. These cell-cultures allow of the continuous observation of the plant during every phase of its development, and they are indispensable for

elucidating and authoritatively deciding all the obscure and critical points in its life-history.

The cell is constructed by fastening with Canada balsam, upon a glass slide, a glass ring 4-5 mm. in height, cut from a piece of combustion tubing, and afterwards ground flat at its edges. A thin covering-glass, of the same diameter as the outer edge of the glass ring, forms the upper side of the cell, and is kept in its place by three minute drops of oil placed on the edge of the ring. To keep the contained air always moist, a few drops of water are placed at the bottom of the cell. Finally, a small drop of the nutritive fluid is placed on the under surface of the covering glass, and in this drop the spore to be cultivated is sown.

This drop of fluid can be examined microscopically in every part, provided that too high magnifying powers are not employed although its margin may be studied with high immersion objectives. With low powers the whole of the interior of the cell can be explored, and the fructifications which are produced can be followed in the air of the cell. If we are willing to sacrifice the culture, we can remove the covering-glass and examine the growing fungus in any way we please.

The cell itself must be kept in an atmosphere saturated with moisture. A tin box with a closely-fitting lid, or covered with a glass plate, will answer this purpose. The slide with the attached cells may be placed on a slab of moistened brick, or the bottom may be covered with moist sand or plaster, and the slides may then be allowed to rest on metal supports (Pl. III, fig. 1). The same box may, in this case, be arranged to hold two series of slides, and a number of such boxes may be placed, one upon the other, in a hot-air bath at a constant temperature, so that a large number of cell-cultures can be carried on simultaneously.

This method allows the observer to follow with the greatest ease, hour by hour, all the details of the germination of a spore, the character of the mycelium which it developes, and every phase in the development of its fructification—in fact, the whole cycle of the life-history of the plant, however protracted that may be. There are other obvious advantages in this plan of study. Not the least, of course, is the elimination of the possibility of error which must always attach to any culture where the access of extraneous germs during the progress of the investigation has not been prevented.

Yet, notwithstanding all precautions, it will often happen that extraneous spores are introduced into the drop of fluid either before or during the culture. But, as the whole drop is under observation, these are immediately detected and their

position noted. No doubt, also, we must trust to chance for success in only introducing a single spore into a drop, but in a large series of experiments chance is sure sometimes to favour us, and if we are careful to sow the smallest possible number, it is generally possible to fix one's attention on a particular spore and keep that steadily under observation.

The minute quantity of nutritive fluid which suffices for successful culture is really astonishing, but the result of our observations leaves no doubt on that head. The liquids which we have most frequently employed are orange-juice boiled and filtered which is an acid and saccharine liquid, and decoction of horse-dung also boiled and filtered which is a neutral and alkaline one rich in nitrogenous principles. The latter is suitable for the culture of a much larger number of species than the first, but it is apparently poorer in nutritive matters, since the mycelium is always much less vigorous in it. It has also the additional disadvantage of lending itself very readily to the development of bacteria, which are destructive to the cultures. Orange-juice, being acid, is not open to this objection, and the only enemy to fear with it is *Penicillium glaucum;* we have given it the preference whenever possible. In addition, we have also employed, for the sake of comparison, brewers' wort, ordinary water, and a saline solution of the following composition, with or without the addition of 7 grms. of sugar:—

Calcium nitrate . . .	4 grammes.
Potassium phosphate . .	1 ,,
Magnesium sulphate . .	1 ,,
Potassium nitrate . . .	1 ,,
Water	700 ,,

It must be remarked that the causes of failure in these cell-cultures are very different, and by no means obvious. The condition of the spores, especially as to age, exerts an effect which must not be attributed to the nutrient medium. Too much importance must not, therefore, be attached to particular features; at the best they will only have a negative value.

General character of the group of Mucorini.

The characters which define a group of fungi should be drawn from the vegetative system or mycelium; the single sexual reproductive apparatus; the often extremely polymorphic asexual reproductive structures, and the order in which these different arrangements succeed one another, and which consequently determines the alternation of generations.

The mycelium of the *Mucorini* always originates from a spore of asexual origin; the sexually produced spore or zygospore never produces mycelium, but developes at once an asexual reproductive apparatus.

Placed under favorable conditions the asexual spore puts out one or more tubes or hyphæ, which elongate and ramify, forming a mycelium, which in the first instance is always unicellular, as in the *Peronosporeæ* and *Saprolegniaceæ*. The more or less granular protoplasm which the hyphæ contain possesses characters different from those met with amongst *Ascomycetes* and *Basidiomycetes*. Later on, as the protoplasm disappears from the hyphæ, septa, more or less irregularly distributed, make their appearance. Usually the hyphæ preserve a complete independence, but in some genera of the family (*Chætocladium, Mortierella, Syncephalis*) they form numerous anastomoses. Their membrane is always colourless. The mycelium sometimes develops exclusively in the interior of the nutrient medium; sometimes it develops itself equally both in this medium and in the air. In some *Mucorini* it may occasionally attach itself to the mycelium or productive apparatus of other plants of the same family, and derive nutriment from them—in fact, become parasitic (*Chætocladium, Piptocephalis, Syncephalis*). But this parasitism appears to be far from essential, since the same mycelium fructifies and vegetates almost equally well when completely isolated. No species of the *Mucorini* appears, therefore, to be parasitic in the fullest and absolute sense of the word.

Asexual reproduction; Sporangia. All the *Mucorini* develope from this mycelium erect hyphæ, in some cases energetically responding to light (*Mucor, Phycomyces*, &c.), in other cases wholly insensible to it (*Rhizopus, Circinella*); their membrane is coloured blue or, at any rate, violet or rose colour by Schultz's solution, and they terminate in a system of sporangia, in which the asexual spores originate by a process of division. Sometimes these sporangia are globular, and they then usually contain a large number of spores, ranging from 500,000 to 10 (*Phycomyces, Mucor*, &c.). Occasionally the sporangia are uniformly monosporic (*Chætocladium*). In *Piptocephalis* and *Syncephalis* the spores are arranged in a narrow sporangium in a single row. The dehiscence of the sporangium takes place in different ways; its membrane may become totally absorbed without leaving any trace as soon as the spores become mature. A drop of fluid secreted from the apex of the sporangiferous hypha envelope the liberated spores (*Mortierella, Piptocephalis, Syncephalis*).

In other cases the membrane persists and the spores escape by a fissure, which may be circular and at the base (*Pilobolus*) or about the middle (*Circinella*); sometimes it is only subsequent to the fall of the sporangia that the liberation of the spores takes place. An intermediate case is produced when the base of the membrane is absorbed and becomes dissolved with more or less facility, leaving merely the dark granules or particles of calcium oxalate, which incrusted it (*Mucor bifidus*, *M. Mucèdo*, &c.; *Rhizopus*, &c.). The septum which separates the sporangium from its hypha is sometimes flat (*Chætocladium*, *Mortierella*, &c.). Sometimes it is more or less strongly bulged inwards, forming the so-called columella (*Mucor*, *Phycomyces*, *Circinella*, &c.). Generally speaking, the *Mucorini* have only a single kind of sporangium. In some genera, however, there are two distinct sporangial systems distinguishable at maturity both by the structure of the sporangia and of the hyphæ which bear them; the spores, however, are identical.

Chlamydospores.—These are a second kind of asexual spores, differing from the first in their mode of formation as well as their structure and formation. They are found in some genera of *Mucorini* and, perhaps in all, and are produced singly in the interior of the hypha by a local condensation and transformation of the protoplasm. They are set at liberty by the absorption of the membrane. The chlamydospores may assume two different forms depending on the degree of differentiation of the portion of the mycelium which produces them. In some cases the mycelium develops branches which elevate themselves into the air, and which, being either simple or ramified, terminate in a large endogenous spore, with a thickened external echinulate or tuberculate membrane. The mycelium may continue its growth for a considerable period without producing any other kind of fructification, and producing only these axial pedicellate chlamydospores. In this state the plants have been often mistaken for *Mucedines*, especially for species of *Sepedonium.*

In other cases it is within the hyphæ themselves and not at the extremities of special branches that the protoplasm aggregates especially towards the close of the period of growth to form asexual spores. They are very irregular in form and size, and are only set free by the destruction of the enclosing membrane; these are, therefore—as opposed to the pedicellate chlamydospores with which, however, in *Mortierella* there are connecting links—mycelial and sessile. They may be terminal or distributed throughout the hypha, and isolated or in rows; they may occur either in the sporangiferous hyphæ

which after the maturation of the sporangium are reduced to the condition of mere mycelial filaments. In fact, they may be found in every part from the cavity of the original spore to the columella of the empty sporangium. But all the genera and all the species of the same genus do not develope them to the same extent. The difference in this respect is especially noticeable in the case of *Mucor*.

Chlamydospores are not confined to the *Ascomycetes*. Woronin has in fact described pedicellate ones in *Ascobolus pulcherrimus*, and we have also met with them ourselves in *Kickxella alabastrina*.

We see therefore that amongst the *Mucorini* the polymorphism of the reproductive organs is very restricted, since it only ranges between the sporangial form, which may, it is true, be of two kinds, and the chlamydial which also put on somewhat different aspects. What, however, is remarkable is, that the asexual spore is always endogenous; it is always formed within a cell at the expense of the whole or part of the protoplasm, and to permit its escape the containing membrane must be either ruptured or absorbed.

Chætocladium at first sight appears to establish a transition between the sporangial and chlamydial forms of spores, but this is only in appearance, since by its mode of formation, structure, and function, the spore of *Chætocladium* is clearly a sporangiospore and not a chlamydospore. The chlamydial form is still far from completely understood, and its occurrence may, perhaps, not be possible in some genera.

Sexual reproduction.—After the production of asexual spores the mycelium of the *Mucorini* produces at particular points, either in the air (*Sporodinia*), on the surface of the nutritive medium (*Phycomyces*), or within it (*Mucor Mucedo*) zygospores, the result of the mutual interpenetration of two protoplasmic masses of distinct origin. Two perfectly similar hyphæ, either straight (*Mucor, Rhizopus, Chætocladium*), or arcuate, like the teeth of a vice come into contact by their swollen extremities. At the same time the protoplasm contained in each cell contracts into a sphere. The double partition between the two protoplasmic spheres is absorbed, and they coalesce into a single mass or zygospore, which increases in size and clothes itself with a tuberculate or echinulate membrane. This is inclosed in addition by the thinner coat of the two original conjugating cells, which becomes coloured (often black), and adapts itself to all the projections of the internal membrane. Generally, the zygospore occupies the whole internal space of the two conjugating cells; in *Piptocephalis*, however, Brefeld has

shown that it only occupies a small part of this space, and projects externally. The zygospore is therefore, like the asexual spores, endogenous in its origin.

It does not germinate till it has undergone a desiccation and has experienced a certain period of rest. Placed in a moist atmosphere it produces at once, without the intervention of mycelium, a sporangial system possessing all the characters which belong to that of the species which produces it. The asexual spores which these contain develope a mycelium, in their turn producing sporangia, chlamydospores, and zygospores.

In the actual state of our knowledge it is difficult to affirm that all these kinds of reproductive apparatus exist in every representative of the group. In point of fact, only one—the sporangial—has been observed in all the species. Zygospores are only at present known in the genera *Sporodinia*, *Rhizopus*, *Mucor*, *Phycomyces*, *Chætocladium*, and *Piptocephalis*. Brefeld does not admit that *Chætocladium* and *Piptocephalis* possess sporangia, but only conidia. According to his views, therefore, the term *Zygomycetes* is more expressive than *Mucorini*, which he restricts to the sporangiferous *Zygomycetes*. This, however, appears to us founded on an error, and there appears, therefore, no reason for changing, on this ground, the old and established name of the group.

Pilobolus.

J. Klein [1] has been led, owing to a faulty method of observation, to the erroneous result that *Pilobolus* is capable of conversion into *Mucor*. It is quite true that he sowed the spores on a slide, but he used a drop of fruit juice covered with a piece of thin glass, and it was on the uncovered edges of the drop, exposed to every source of error and inaccessible to rigorous examination, that he observed the development and fructification of *Mucor*.

It is rather remarkable that the suspicions of Klein were not aroused by the unexpected nature of his results. Thus the spores of *P. crystallinus* sown in a watchglass produced a *Mucor* with sporangia. Spores of the same crop of *P. crystallinus* sown in horse-dung decoction produced the fructification of *P. crystallinus*. Spores of this second generation sown on saccharine fruit juice produced, in their turn, a *Mucor*, but one different from the first. We therefore arrive at the result, not a little surprising, that *Pilobolus*-spores

[1] "Zur Kenntniss des *Pilobolus*," 'Pringsh. Jahrb. f. w. Bot.,' viii, pp. 362—372.

produce a different species of *Mucor*, according to the generation they belong to. But the spores of these species of *Mucor*, when sown in their turn, only produced a similar kind of *Mucor*, and never returned to *Pilobolus*.

When these results were published we were naturally anxious to confirm them. But both the spores of *P. œdipus* and of *P. crystallinus* have refused to germinate with us in the juice of cooked plums, or, at any rate, they have only produced very short tubes, and nothing more has come of them. It is quite true that some of our cultures yielded abundance of *Mucor*, and belonging to more than one species, but we were quite prepared for this, for we had previously detected the presence of their spores. In one case amongst seventeen spores of *Pilobolus*, three spores of *Mucor* developed a vigorous mycelium and abundantly fructified. Another time, among nine spores of *Pilobolus* there was a spore of another species of *Mucor*, and this also fructified. In other cases, extraneous spores produced *Botrytis cinerea* and *Alternaria tenuis*.

PHYCOMYCES.

This plant was discovered by C. Agardh on the walls and wood-work of oil mills and storehouses for oil in Finland.[1] Being unacquainted with its reproductive apparatus, and being especially struck with its dark green colour and the shining aspect of its large flattened filaments, he supposed it to be an alga, and named it *Ulva nitens*—a name which he still retained for it in 1823.[2] In this year, however, G. Kunze met with it under the same conditions in Saxony, and especially in the neighbourhood of Leipzig and Dresden; having detected the columella which terminates the fructiferous hyphæ and the elongated spores with which the columella is covered, he assigned it a place amongst Fungi, under the name of *Phycomyces nitens*.[3] But the existence of the sporangium, which envelopes at first the whole of the spores together with the columella, appears to have escaped his notice. It consequently did not occur to him to place his plant near *Mucor*, and, on the contrary, he thought that it was allied to *Aspergillus*. More recently Berkeley met with this organism on oil-casks, and observed the structure of the sporangium previous to dehiscence. The analogy which it presents with that of *Mucor* led him to place it in that genus

[1] 'Synopsis Algarum Scandinaviæ,' 1817, p. 46.
[2] Species "Algarum," 1823, i, p. 425.
[3] G. Kunze, 'Mykologische Hefte,' ii, 1823, p. 113.

under the name of *M. Phycomyces*.[1] De Bary, who had no better materials for study than those contained in the herbarium of Kunze, also describes it under Berkeley's name.[2]

The plant is only rarely met with. It does not appear to have been observed in France till recently :— 1st, at Toulouse, by MM. Joly and Clos, on a rag used for wiping a hydraulic machine and impregnated with oil; it was also found on the parts of the machine itself, on the oil-vessels, and on the flooring of the building; 2nd, by MM. Crouan,[3] in a candle manufactory on tallow scum. These authors have, however, added nothing to our knowledge of this curious plant.

The circumstances under which this species has occurred has supported the opinion that it is exclusively addicted to fatty matters. This will be seen not to be the case, and it is this which explains why M. Carnoy, having met with it at Rome on human excrement and afterwards cultivated it on slices of orange and citron, failed to identify it with the plant of Kunze, and described it as *Mucor romanus*, a new species.[4] We did not make this identification till after we had long cultivated the plant, and had discovered one by one the facts in its history correctly described by Carnoy.

We first heard of it from a dyer at Wesserling (Alsace) as a large kind of *Mucor*, which made its appearance in acid cochineal dye. The spores of the specimen sent to us were sown in ordinary cochineal dye, and also in other media, but without any result. We then had recourse to M. Lange-Desmoulins from whom the dye originally came, and the supply which we got from him, when placed under a bell glass in the laboratory, developed, in a few days, a magnificent crop of *Phycomyces*. It was evident that the dye from his establishment was naturally impregnated with the *Phycomyces*, since it developed upon it in continuous succession, and it was also evident that success in its cultivation depended upon the freshness of the spores, which rapidly lose their power of germination—a circumstance which explains the feeble power of dissemination possessed by the plant, as well as its rarity. We soon had an additional proof of this. Our first series of cultivations, carried on during several months, were interrupted by the vacations. On our return it proved impossible to recommence them. The spores of the old crops had lost by a desiccation of two or three months their power of germination. The plant appeared also to have disappeared from

1 Berkeley, 'Outlines,' p. 28 and 407.
2 'Mém. de l'Acad. des Sc. de Toulouse,' 7 Déc. 1865.
3 'Florule du Finistère,' 1867, p. 13.
4 'Bull. de la Soc. Roy. de Bot. de Belg.,' t. ix, 1870, p. 162, et seq.

the dye of M. Lange-Desmoulins. At length it made its appearance on horse-dung placed under a glass shade in the laboratory, and its long, isolated filaments developing at considerable distances, one after another, proved that they originated by the germination of so many zygospores. This enabled us to recommence a second series of cultivations, especially as we received at the same time from the dye manufactory a fresh fertile tuft of the plant.

These facts prove that *Phycomyces nitens* may develope in the most different media, oily or fatty, excrementitious, horse-dung, or dyes. The only necessary condition is the presence of fresh spores or zygospores. It is seldom met with, only because the asexual spores speedily lose their germinating power. Once established in a place favorable for its complete development, it is indefinitely perpetuated by zygospores, but it quickly disappears from localities where the formation of zygospores is prevented.

We have cultivated *Phycomyces nitens* (1) in pans on cochineal dye, excrement, pounded cochineal, oranges, bread; (2) in cells on horse-dung decoction, cochineal dye, orange juice, and also our saline solution, both with and without sugar.

Spores.—The asexual spores of *Phycomyces nitens*, which will serve as our point of departure, vary a little in form according as they belong to the small sporangia of young mycelium, or to the large sporangia which terminate the long filaments arising from the adult mycelium. The first are spherical (Pl. III, fig. 2*a*), or slightly ovoid, ·016 mm. in diameter; their centre is intensely yellow and granular; their coat, on the contrary, and the peripheral portion of their protoplasm colourless and homogeneous. The others are of a very elongated ellipsoidal form, often flattened, or even concave upon one of their sides, with a transverse diameter a little less than that of the preceding ones, that is to say, ·012 to ·015 mm.; they attain a length of ·020 to ·030 mm. (fig. 2*b*); their central yellow matter forms an axile granular band. It is, therefore, to the protoplasm of their spores that the sporangia owe the golden-yellow colour which they possess as long as their coat remains transparent and colourless. As long as the spore is young its membrane has no distinct internal lining of protoplasm; later on it separates, and acquires a double contour; at the same time the protoplasm becomes more granular (fig. 2*c*).

Placed in a moist medium, but in conditions which preclude their development, the spores alter; the protoplasm exhibits granules which become larger and larger, and finally

concentrates itself into a variable number of spherical nodules sufficiently regular to present sometimes the aspect of spores in an ascus (fig 3 *a*). Later on the coat, often bristling externally with bacteria, becomes pierced at several points, and these nodules are set at liberty. But the nodules, even under the most favorable conditions of the medium, never germinate. When dried the spores lose equally their power of germination; we have not succeeded in making them germinate after three months. The spores, therefore, do not long resist either moisture or dryness.

Germination.—In ordinary water germination will not take place; it does so, however, very readily in a cell in the saline solution without sugar, in orange-juice, horse-dung decoction or cochineal dye, and in pans on slices of orange, horse-dung, different excrements, cochineal dye, or broken cochineal. Placed in a film of liquid under a covering of glass, so as to have a very small supply of air, the spores failed to germinate; those at the extreme border of the film produced filaments, those within it none. They appear, therefore, not to possess the power which the spores of *Mucor Mucedo*, *Thamnidium*, and *Helicostylum*, have of germinating by a kind of gemmation, and of giving rise to chains of irregularly-sized cells.

The spore first of all loses colour, swells, and absorbs the nutrient fluid, without, however, emitting a filament; it thus doubles its size and becomes ovoid. It then puts out from one of its extremities, or from both, a thick hypha, which elongates, forming, at the same time, pinnately-arranged branches destitute of partitions. If the young spore had not previous to germination acquired a double contour there is no exospore pierced by the hypha, and the external contour of the spore is merely darker than that of the filament which proceeds from it; but if the coat had become separated from the spore by an internal contour the spore in dilating ruptures an exospore, which often detaches itself over its whole surface, continuing to partially invest it (fig. 2 *d*). After having thus developed in the liquid about forty-eight hours after sowing, the mycelium sends some of its branches into the air within the cell, which ramify there abundantly, a first point of difference with the true species of *Mucor*. Besides these large aërial branches, short branches occur here and there on the submerged filaments which are either simple or have tuft-like ramifications terminating in a point, and forming beneath the apex a sort of forest of spine-like hairs.

The mycelium begins to develope its fructification from the

second day in the saline solution or the decoction, both of which are feebly nutritive liquids and in which its vegetative activity is soon exhausted; in orange juice this did not take place till the third day. In both cases the temperature was about 59° Fahr. Abruptly-swollen branches, club-shaped in form, make their appearance upon the hyphæ both in the nutritive medium and in the air. Sometimes these branches prolong themselves directly into an equal number of sporangiferous hyphæ; but most frequently they first divide at their swollen apices into numerous branches of which ordinarily one (fig. 15), sometimes two or three (fig. 16), develope into sporangiferous hyphæ, while the rest, which are short and pointed, form a tuft of rootlets. Sometimes these rootlets reduce themselves to one or more rounded protuberances situated towards the base of the sporangiferous hypha and giving to its lower region an undulating outline. The sporangiferous hyphæ of *Phycomyces* are normally therefore produced in groups, and this is indicated generally by the presence of sterile hyphæ, in the form of rootlets. This is a second character which separates our plant from *Mucor*, and indicates a nearer affinity with *Rhizopus*.

There are often also a certain number of the branches which are swollen into a club- or pear-shaped form and do not erect themselves above the surface; instead of producing a sporangiferous hypha, which would seem to have been their first destination, they become abruptly attenuated, and are merely prolonged into a mycelial filament (fig. 17). But the protoplasm never aggregates in the interior of these basal swellings of the mycelial ramifications, even to the extent of simulating a chlamydospore, and we have never, indeed, under any circumstances, met with a single one in *Phycomyces*. Occasionally when the process of germination has been prematurely arrested, as by the development of bacteria in the decoction, certain portions of the hyphæ, in which the protoplasm preserves its vitality after the rest of the tube is destroyed, are partitioned off. This is certainly a tendency towards the formation of chlamydospores; but there is no condensation of the protoplasm, and it never invests itself with a special membrane. Later on, as in the case of the spores, this isolated protoplasm undergoes a gradual alteration separating into tolerably regular ovoid or fusiform nodules, which to a certain extent have the appearance of spores contained in an ascus but appear to be incapable of germination. The figure 3 *b* represents one of these cavities, which happens to have been formed at the very base of the germinating hypha, and corresponds to the original cavity

of the spore, being still covered with the exospore and filled with fusiform nodules.

We do not think it necessary to describe in detail the structure of the sporangium, the development and dispersion of the spores, or the mode of elongation of the sporangiferous hypha; these phenomena take place exactly as in *Mucor*, and Carnoy has fully described them. We will merely remark that the membrane of the sporangiferous hypha does not become incrusted with granules of calcium oxalate, and that it becomes gradually coloured from below upwards, before the formation of the sporangium, in a very remarkable manner, which is in singular contrast with the golden-yellow colour of the protoplasm filling the apex of the tube, and later on forming the spores. Beginning with bronze green it gradually becomes reddish brown, or violet brown; its surface is shining, and exhibits iridescent reflections and a bright metallic lustre, a circumstance to which the plant owes its specific name and which allows of its immediate identification. The membrane of the sporangium encrusts itself, on the contrary, with calcium oxalates, which gives it a dull and velvety aspect and renders it opaque and dark.

We will now trace the progressive advance in the vigour of the fructification which accompanies the more vigorous growth of the mycelium in different nutritive media.

In a drop of the saline solution the spores form a mycelium which begin to fructify at the end of the second day; the spores are mature about sixty-five hours from the time of sowing, the temperature being 57° F. The first sporangiferous hyphæ are not more than ·100 mm. in length, and may even be no longer than ·024 mm.; the corresponding diameter of the sporangium may be no more than ·025 mm., and it may contain as few as ten spores with a very depressed columella. The hyphæ produced on successsive days become gradually taller with sporangia correspondingly larger; their columella, which is more and more prominent, becomes at first hemispherical, then cylindrical, and the spores are more oval and more numerous. These changes are all concomitant. At length, after twelve days, the sporangiferous hyphæ produced outside the cells on the mycelium which has insinuated itself between the covering glass and the cell have a length of as much as seven to eight centimetres, a proportional breadth, and a very large sporangium. Such a result is no doubt astonishing when one reflects that, before the formation of a hypha of this kind takes place, the mycelium nourished by this minute drop of a saline solution has produced successively larger and larger sporangia. It is still more

astonishing if one compares it with the conditions of the medium ordinarily affected by the plant, since nothing can be more different than a mass of some greasy substance and a drop of our saline solution.

In orange juice, which is evidently more nutritious, the mycelium developing at first more vigorously, fructifies rather later, about the third day; but the branches first formed are stronger, taller, and the sporangia larger, although having wholly spherical spores and a depressed columella. Just as with the saline solution a progressive increase takes place, and the last hyphæ which form in the moist chamber in which the growing cell is placed attain a length of as much as ten centimetres.

Sexual reproduction ; Zygospores.—In the cell-cultures, no doubt owing to the unsuitableness of the medium, and even on fruit in pan cultivations, we have failed to obtain the sexual apparatus. On crushed cochineal and on cochineal dye, on the contrary, we have repeatedly obtained it in the greatest abundance. The mycelium produces at first its forest of sporangiferous hyphæ, shining and iridescent. If, when new hyphæ cease to be developed, we remove the whole of this forest of hyphæ, we see on the surface of growth large black grains, which catch the eye at a first glance on the red background: these are the zygospores. It is easy then to meet with them in all the states of development about to be described.

The hyphæ which conjugate to form the zygospores are slender and stand erect on the surface of the substratum; they are analogous to the hyphæ forming the tufts which we described in the cell-cultures. Two of these hyphæ come into close contact through a considerable length, and dovetail with one another by alternate protuberances and constrictions. Some of the protuberances are frequently prolonged into slender tubes (fig. 4). At the same time the free extremities of the hyphæ dilate and arch one towards the other until their tops touch, forming a kind of vice, of which the teeth rapidly increase in size. Each tooth forms a partition which cuts off a cell, at first hemispherical (fig. 5), and afterwards becoming cylindrical by pressure (fig. 6). In each of these discoid cells the protoplasm aggregates itself into a mass. The double membrane at the point of contact is absorbed, and the two confluent masses of protoplasm form a zygospore, which is invested with a tubercular coat, and enveloped by the primary wall of the two conjugating cells (figs. 10 and 11).

While this is taking place the two arched cells develope on the zone adjoining the walls which separate them from

the conjugating cells a series of repeatedly dichotomous processes (figs. 11, 12, 13). These processes appear in the first place upon one only of the arcuate cells, and in successive order. The first makes its appearance above upon the convex side; the succeeding ones to the right and left in descending order: the last is in the concavity underneath (figs. 7 and 8). It is only after the development of this that the first process makes its appearance above upon the other cell (fig. 9), followed by the others in the same order. The processes grow and dichotomise in the same order in which they are developed.

The first dichotomy always takes place in the plane, passing through the point of dichotomy as well as the line joining the centres of the conjugated cells (figs. 9, 10); the others follow in planes alternately at right angles with one another. The two branches of the first dichotomy are slightly unequal; that which is situated next the zygospore is the most developed, and lying upon it dichotomises again repeatedly, interlacing its branches so as to envelope and protect the zygospore. These dichotomous processes are nothing more than branches of the arcuate cells; in fact, when the "vice" is arrested in its development, it is not unusual to see one or more of the processes already formed develope into ordinary mycelial hyphæ (fig. 14). During all these changes, while the zygospore enlarges, the wall of the arcuate cells becomes coloured brown. This coloration is more marked on the convex side, and it shows itself first in the cell on which are produced the first dichotomous branches and which long retains a darker tint than the other. The zone of origin of the processes and the processes themselves have their wall of a deep black, while the walls of the conjugated cells which continue to clothe the zygospore during the whole period of its development is itself a bluish-black (figs. 11, 13). When its development is complete the zygospore may attain $\frac{1}{3}$ mm., but many occur which are much smaller. It is more developed on its external than upon its internal side, and its lateral faces by which it is attached to the teeth of the vice are slightly inclined one to the other, which is the result of the curvature of the primary cells. By pressure the black, thin, and brittle coat which envelopes the zygospore is ruptured, and the coat of the zygospore itself is exposed as a thick, cartilaginous membrane studded by large irregular protuberances. The contained protoplasm, like that of all zygospores, is very rich in fatty matters. The dichotomous processes which interlace their branches round the zygospore as if to protect it distinguish the reproductive apparatus of

Phycomyces nitens from all others which are at present known. The previous connection of the two conjugating hyphæ and their terminal curvature in the form of a vice grasping the zygospore can only be compared with the arrangement in *Piptocephalis* which Brefeld has made us acquainted with.

The mode in which the processes are developed indicates that there is a difference in the age and properties of the two teeth of the vice, similar as they appear in other respects, and similar as are the conjugating cells. We may trace in this dissimilarity a first step in the differentiation of the two elements whose union forms the germ-cell, an indication as yet feebly marked, but still very distinct, of sexuality in the process of conjugation.

We have not yet succeeded in making these zygospores germinate; but it is probable that the process is similar to what takes place in the case of zygospores of which we know the mode of germination, especially those of *Mucor fusiger* and *M. Mucedo*. We were the first to describe the zygospores of this last plant.[1] A short time after we discovered their mode of germination. Brefeld has also recently figured and described these organs and their germination.[2] We shall not touch on this point, therefore, except to detail some new observations. The black membrane, which is generally regarded as belonging to the zygospore, of which it forms the exospore, is really absolutely foreign to it, since it is nothing more than the original cell-walls of the cells which have conjugated. This black membrane ruptures in germination. The thick, black, cartilaginous, colourless, tubercular coat splits also on one side, and its delicate internal coat elongates itself externally as a tube which is filled with protoplasm and oil-drops; it is covered in its lower third with granules of calcium oxalate, while it is smooth higher up; it attains a height of three centimètres, and terminates in an ordinary sporangium. Thus, the zygospore produces directly, not a mycelium, but an asexual reproductive apparatus. The axis of this apparatus—that is to say, the axis of growth of the new individual plant, is perpendicular to the line joining the centres of the two conjugating cells—that is, to the coalescent axes of growth of the two sexual branches. In the zygospore, therefore, the protoplasm has, so to speak, a polarity (*est orienté*), the direction of which is at right angles to the line joining the centres of the two conjugating masses of protoplasm, or oospheres. It is also probable that each oosphere is polarised in a direction at right angles to the

[1] 'Comptes Rendus,' Ap. 8, 1872, vol. lxxiv, p. 1000.
[2] 'Bot. Unt. ub. Schimmelpilze,' p. 31, pl. ii.

axis of growth of the conjugating cell, from which it is produced. The two oospheres have their axes parallel and consequently when fused produce a zygospore whose axis preserves the same direction. In this change of direction in the axis of the new individual we find an additional analogy with the sexual process in Algæ.

Usually, the amount of nutriment stored up in the zygospores is exhausted by the formation of the terminal sporangium, and this is the only case described by Brefeld; but in the germinations which we have watched ourselves we have often seen the formation of a partition at about one third of the length of the principal filament from its base, and below this partition a strong branch given off, which is also terminated by a large sporangium. In one instance this branch also exhibited near its base a partition beneath which a small branch was given off, terminated by a small sporangium with very few spores and a minute columella.

Contrary to the opinion of Berkeley and De Bary, we regard this plant as belonging to a distinct genus. Its partly aërial mycelium, the mode of origin of the fructiferous hyphæ in groups with tufts of rootlets, the remarkable colouration of the protoplasm of the spores and of the wall of the fructiferous hypha, and above all the curious vice-like arrangement of its reproductive apparatus and the dichotomous processes with which it surrounds the zygospore, are characters which are not met with in any species of *Mucor*. A similar sexual apparatus only occurs in *Piptocephalis* which is remotely allied to *Mucor*; and the dichotomous processes have not at present been detected in any others of the group. From all these points of view this plant merits a generic rank.

Brefeld has proceeded hastily in following De Bary and Woronin and in reducing all the types of *Mucorini* to the two genera *Mucor* and *Pilobolus*. It is true that *Chætocladium* and *Piptocephalis*, which he holds to be distinct, are, according to him, not *Mucorini* at all. But in this we ourselves believe that he is mistaken.

Thamnidium.

Link described in 1816 under the name of *Thamnidium elegans* a Mucorinious fungus of which the principal fructiferous hypha terminated in a large sporangium, with a columella similar to that of *Mucor*, and which produced laterally numerous repeatedly dichotomous branches, of which the final ramifications, according to him, bore spores.[1]

[1] Link, 'Observ. in Ord. Nat. Plant. Dissert.,' i.

Fries, only regarding this production of lateral spores as a specific character, placed the plant in the genus *Mucor* under the name of *M. elegans*.[1] But Corda showed subsequently that the reproductive lateral organs are not spores, but small sporangia destitute of a columella and containing four spores similar to those of the terminal sporangium.[2] Like Fries he only regarded this system of small lateral sporanges as a specific character, and as the terminal sporange exhibited all the characters of his *Ascophora Mucedo*, he placed the plant next to it as *A. elegans*.

However, Eschweiler had long previously described and figured under the name of *Melidium subterraneum* a dichotomous fructification with small sporangia destitute of a columella and containing a small number of spores, usually four. This is identical with the dichotomous lateral system of Link's *Thamnidium*, of which Corda ascertained thetrue nature, and which, as we now know, may occur isolated and deprived of its large terminal sporangium. The observations of Link and Eschweiler relate to one and the same plant, and mutually complete one another.

De Bary and Woronin,[4] going further than Fries and Corda, have asserted the identity of the terminal sporangium of *Thamnidium* with that of *Mucor*. According to their view the dichotomous system of small spores is a reproductive structure which belongs to *Mucor Mucedo*, but which only appears on the ordinary filaments of this plant under certain conditions. At the commencement of our researches we had at first adopted this view, but we soon found that the supposed identity of the large terminal sporangia in the two plants was an error, and that *Thamnidium* is a perfectly autonomous species.

It will not be necessary to describe here in detail the mature fructification; an erect filament, which may attain five or six cm. in height, terminates by a large sporangium with a columella, and produces, laterally, one or more tiers of isolated or whorled dichotomous branches, the ultimate ramifications of which have small sporangia destitute of columella. This is not, however, the only form met with in pan cultivations. Simple and naked filaments terminating in a large sporangium are also met with as well as filaments equally simple, but ending in dichotomous fructification with small sporangia, *Melidium* Eschw. (fig. 18, *a*—*k*). Later on

[1] Fries, 'Systema,' i, 183.
[2] Corda, 'Icones Fungorum,' iii (1840), p. 14.
[3] Eschweiler, 'De Fructif. gen. *Rhizomorphæ*, Comm. Elberfeld,' 1822.
[4] 'Beitrag. z. Morph. und Phys. der Pilze,' ii (1866), p. 16.

the first may produce simple lateral branches with a large sporangium; the second may also give rise to new lateral branches, but these are dichotomous and bear small sporangia.

Thus, in pan cultivation we may meet with one or other of the two forms of sporangia, either exclusively or both together in different regions of the mycelium, and the spore-bearing systems will be accordingly either homogeneous or heterogeneous. When both kinds of sporangia occur on the same hypha sometimes the large sporangium is borne on the summit, and the small sporangia laterally; and this is the most common combination, but sometimes it is the reverse. The hypha terminated by a tuft of small sporangia bears a lateral branch with a large sporangium. The two arrangements may even occur successively in the same complex system; an erect hypha with a large sporangium bears a horizontal branch terminated by a dichotomous tuft; this produces in its turn an oblique lateral branch terminated by a large sporangium, which in its turn produces a lateral branch with small sporangia (fig. 18, *i*).

The two forms of sporangium are always sharply distinguishable. The large sporangium is always borne by a simple hypha, and has a large columella, a wall incrusted with granules and fine spicules of calcium oxalate which becomes diffluent in water, dispersing the granules and spicules and a large number of spores which in this way are disseminated. The small sporangia are always produced by dichotomous hyphæ. Their short and very fragile pedicels are separated from their cavity by a partition, which is flat or only slightly curved; their wall is also studded with more or less prominent granules of calcium oxalate, but is not soluble in water; their spores are usually four in number, but may be as many as six, eight, or ten, or as few as three or two, or even be reduced to one filling the whole sporangium. It is by the falling off of these sporangia and the final rupture of the membrane that the spores are set free. Whether produced by a large or a small sporangium the spores are in all other respects similar; they are homogeneous, colourless, or bluish, oval, about ·008 to ·010 mm. in length, and ·006 to ·008 mm. in breadth.

When the sporangium contains only a single spore, which occasionally happens almost exclusively over a large extent of the crop, the spore is spherical, intimately applied to the membrane of the sporangium, from which it is distinguished with difficulty (fig. 20), but from which it can be freed by pressure; it measures often ·012 mm. in diameter, but it may vary from ·008 mm. to ·016 mm. It is probable that it is

under this form that *Thamnidium* was discovered by Link, which explains how this author came to describe the sporangia as spores.

Cell-culture has shown that, on the first appearance of the mycelium, there are innumerable transitions between the two forms of sporangia sown in a cell; in ordinary water the spores did not germinate; in the saline solution, on the contrary, they germinated, but their hyphæ speedily became empty, owing to the protoplasm concentrating itself at certain points and forming isolated chlamydospores, but not producing fructification. In horse-dung decoction and orange juice, on the contrary, it succeeds well.

The oval spore at first swells, becomes spherical, and continues to increase for some time; then, without the least trace of a ruptured exospore, it puts out one or two hyphæ, which ramify progressively, and form here and there on its principal ramifications attenuated branches, divided into tufts of radicles, and separated from the main branch by a partition near their base. After forty-eight hours the mycelium thus formed has produced in the air within the cell a large number of erect sporangiferous branches. They bear sometimes a single sporangium, variable in size (fig. 18, *a, g*), spores of which may, if the nutrition be insufficient, be reduced to two or even a single one, sometimes two or three, or four to thirty-two or more sporangia (fig. 18, *b, c, d, e*).

In proportion as the dichotomy increases, the size of the sporangia and the extent to which their septum bulges inwards decrease, and finally they only have four spores. The earliest fructification produced by the young mycelium presents all possible transitions between the two kinds of hyphæ and sporangia. Amongst these transitions small sporangia without a columella terminate simple hyphæ, and large sporangia with a distinct columella terminate dichotomies, in which case the spores are often very unequal in size; and all these transitions occur not only on a mycelium, which is the product of numerous spores, but even upon that which is derived from a single one. One branch of a mycelial hypha, for example (fig. 19), will produce a single large sporangium, while another will terminate in a system three times dichotomous with eight moderate-sized sporangia.

We have also observed on the branched hyphæ horizontal branches, usually also dichotomous, develope with or without a septum, and bearing sporangia both smaller and more numerous than those of the terminal dichotomy (fig. 19). In such cases it often happens that when the sporangia of the

terminal dichotomy contain sixteen spores, those of these secondary lateral ones will only contain a single spherical spore of from ·005 to ·006 mm. These spores, in germinating, either rupture the closely-applied sporangium (fig. 20) or the spore pierces its wall, elongating directly into a hypha, and leaving its basal portion enclosed.

It is important to remark that in our cell-culture the fructification was often exclusively composed of dichotomous hyphæ with small sporangia, without a trace of the large hyphæ bearing a single sporangium.

We have also observed the germination of the spores of *Thamnidium* in a layer of a nutritive liquid, such as orange juice, so arranged as to prevent, as far as posssible, the access of air, and to prevent the plant from fruiting. Under these conditions the spores absorb nutriment and swell into large homogeneous spheres, which, by a process of gemmation, produce more or less irregular chains of sphærous cells. When the mycelium is subjected to the same treatment the hyphæ form also at their extremities chains of irregular joints, in which the protoplasm temporarily condenses, and which are an approach, therefore, to chlamydospores. Under the same conditions we have also seen short branches of the hyphæ swell at intervals, often at their extremities, into large spheres, with granular walls, and containing protoplasm filled with large vacuoles.

We have not as yet detected the zygospores of *Thamnidium*.

Chætostylum.

Fresenius in searching for *Thamnidium* discovered two other *Mucorini*. One is *Piptocephalis Freseniana* of De Bary; the other is the plant to which we have now given the name of *Chætostylum Fresenii*.[1] Fresenius believed it to be a reproductive system belonging to *Mucor Mucedo*. It is also very probable that it is identical with the reproductive system ascribed by Klein to the same plant, and named by him *Bulbothamnidium elegans*.[2]

Chætostylum occurs mixed with *Chætocladium* upon horse-dung, and closely resembles it in appearance. It differs, however, in having a strictly definite instead of indefinite mode of growth. It is heterosporangious, like *Thamnidium*, and may have large sporangia with a columella, and a diffluent wall, terminating simple and vertical hyphæ, or small

[1] Fresenius, 'Beitr. z. Mykol.,' 1863, p. 96.
[2] Klein, 'Verhandl. dev. k. k. Zool. Bot. Ges. in Wien,' 1870, t. xx.

caducous sporangioles destitute of a columella. All the branches except those which bear the sporangioles terminate in a point and the branches of each successive order, which are shorter than those of the preceding, are placed in a kind of false verticil on a more or less swollen dilatation (fig. 21). Whatever the size of the sporangium the spores are always nearly uniform. They are colourless or slightly bluish, oval, and ·008 mm. in length, by ·005 in breadth.

CHÆTOCLADIUM.

The type of this genus was first described by Berkeley and Broome as *Botrytis Jonesii.*[1] This was erected into a genus by Fresenius, who called it *Chætocladium Jonesii.*[2] Quite recently it has been studied by De Bary and Woronin.[3] At first, we ourselves accepted the conclusion arrived at by these latter writers, that *Chætocladium* belonged to the cycle of *Mucor Mucedo.*[4]

Chætocladium Jonesii.—By sowing, unmixed with other spores, in a drop of orange juice or decoction, in a cell, a small number of the reproductive bodies of this species, or better still, a single one, and by watching from hour to hour its development, it is easily proved that the reproductive bodies of *Chætocladium Jonesii*, regarded hitherto as simple acrogenous spores, such as those of *Botrytis*, are really small caducous sporangia, containing only a single spore, like those of *Helicostylum*, *Thamnidium*, *Chætostylum*, in fact, that *Chætocladium Jonesii* is perfectly independent of *Mucor Mucedo*, or of any of the *Mucorini*, either as a reproductive system or as a parasite.

These reproductive bodies (fig. 22), when detached from the plant at their maturity, are a more or less slaty blue. Their external surface bristles with calcareous granules, more or less developed, which have not escaped the observation of Berkeley and Broome, and a small portion of the broken pedicel is sometimes still attached (fig. 23, *a*). It is not rare to find an external membrane distinguishable from an internal spherical body, since the spore does not in this case completely fill the cavity of the sporange; but it is frequently difficult to observe this, from the spore being everywhere in intimate contact with the inner wall of the sporangium; this is also the case with the monosporic spo-

[1] 'Ann. and Mag. Nat. Hist.,' 2ad ser., 1854, xiii, pl. 15.
[2] 'Beitr. z. Mykol.,' 1863, p. 97.
[3] 'Beitr. z. Morph. u. Phys. der Pilze,' 2nd ser., 1866, pl. 18.
[4] 'Comptes Rendus,' Ap. 8, 1872.

rangioles of *Thamnidium*. By pressure the thin granular, brittle, and greyish membrane of the sporangiole is easily broken, and the smooth, often dark slate-coloured spore is extruded (fig. 23, *b*). But germination affords the most convincing proof of the sporangial nature of the reproductive body.

A fruiting branch of *Chætocladium Jonesii*, terminating in a point, and bearing upon its middle dilatation eight ripe reproductive bodies, still attached to their pedicels, is placed in a drop of orange-juice in a cell. Seven hours afterwards the external membrane is ruptured, and the contained spore either completely (fig. 23, *cc*) or partially (*d*) extruded, requiring in the latter case a little manipulation to detach it from the sporangiferous branch. The spores now change colour, and gradually swell to three or four times their original diameter without, however, changing form; a large vacuole occupies its centre (fig. 24, *a*). They then become oval, and afterwards form projecting angles (*b*, *c*, *d*), which develope into short stout tubes, spreading in all directions and dividing immediately into close or palmate dichotomies (fig. 24, *e* to fig. 27), and forming a small mass of mycelium, which grows slowly by additions to its periphery, attaining sometimes the size of a pin's head. No long diffuse branching mycelium with radicles is formed, as in *Mucor*, where the mode of germination is altogether different. This enables us to detect as early as the second day an accidental admixture in our cell-culture of *Mucor* spores.

It is not till three or sometimes four days from the time of sowing the spores that branches of these white mycelial masses erect themselves into the air to ramify in all directions. These long aerial hyphæ bear laterally either singly or in verticils of two or three branches, which terminate in a point, and which bear in turn at about their middle two or three shorter pointed branches. These last bear on a swelling at their middle, a small number of slender simple, or sometimes dichotomous pedicles, each terminated by a monosporic dark slate-coloured granular sporange, and measuring ·006 to ·008 mm. in diameter (fig. 22). As the fructification develops, the protoplasm, slowly accumulated at first in the large radiating mycelial hyphæ is used up, and the hyphæ become empty. At the same time the extremities of some of them abruptly taper off, while others become enormously inflated into large balloon-like bodies, with a granular surface, and often prolonged into a point (fig. 28, *a*, *b*). But we have never detected chlamydospores.

This is the uniform course of development in *Chætocladium*

Jonesii, which cannot therefore be normally parasitic on *Mucor.* Inasmuch also as it reproduces itself for an indefinite number of generations, it can have no genetic bond either with *Mucor Mucedo,* or any other of the *Mucorini.*

The aerial sporangiferous hyphæ of *Chætocladium,* like those of *Circinella* and *Rhizopus,* have an indefinite growth after the fashion of a liane.[1] But it is not rare to find one of the vegetative hyphæ put out laterally a short and thick branch, which frequently divides repeatedly dichotomously, and forms a white tubercle tangent to the hypha or even enveloping it entirely. These tubercles or mycelial masses are altogether similar to those which proceed from the germination of the spores. Some of their branches may be prolonged into the air as new, fructiferous, indefinite hyphæ. They are, perhaps, homologous with the tufts of radicles which develope on the aerial indefinite hyphæ of *Rhizopus,* and are the point of origin of new fructifications.

Sometimes it happens that the mycelial mass resulting from germination is very much reduced; the spore puts out five or six palmate tubes, one of which immediately raises itself in the air and becomes covered with fructification, while the others are like the fingers of a glove, and terminate at a short distance from the spore. In this case the submerged mycelium is a mere base of support for the aerial hypha, producing fructification.

Besides sowing the pure spores of *Chætocladium Jonesii,* we sowed them mixed with those of *Mucor Mucedo.* The mycelia of the two species so different in their characters, the one condensed into masses, the other diffuse, vegetated as if they were independent, and without forming any attachment the one to the other. The first put out its more slender branching sporangiferous hyphæ, the other its simple ones, but wherever a hypha of *Chætocladium* came in contact in the air with one of *Mucor,* an intimate adhesion took place, and at the point of contact the filament of *Chætocladium* put out large branching processes, which, becoming felted together, formed round the two hyphæ a large white tubercle, from which new fruit-bearing filaments of *Chætocladium* originated. If the hypha of *Mucor* is very young and still in process of elongation when thus attacked, it ceases to develope, but if its protoplasm has already accumulated in its terminal dilatation it produces a sporangium, and forms and ripens its spores.

[1] Sometimes degraded forms which are more or less definite in their growth are produced in liquids, such as horse-dung decoction, which are insufficiently nutritive (fig. 37, *a*—*l*).

The *Chætocladium* grows in the air amongst the tall, rigid hyphæ of *Mucor* like parasitic lianes among trees. But the plant is not, strictly speaking, parasitic, though it can live parasitically and becomes more vigorous when it does so.

It is necessary in growing the two plants together to avoid sowing too large a number of spores of *Mucor*. These germinate sooner than the others and if present in any quantity completely suppress their growth leading to the belief held at first by ourselves, as well as by De Bary and Woronin of an imaginary transformation of the *Chætocladium* into the *Mucor*.

Chætocladium Brefeldii.—We have given this name to a species very similar to the preceding, but more slender in all its parts, and which differs from it by its bluish sporangia, which are much smaller, being only from ·003 to ·005 mm. We believe it to be identical with that studied by Brefeld, and of which he obtained zygospores.

Brefeld believes that the reproductive bodies of this species are simple naked conidia, and that it is parasitic on *Mucor Mucedo* and *Rhizopus nigricans*. He deduces this parasitism from two supposed facts—(1) that it fails to develop, either alone or associated with any other of the *Mucorini ;* (2) if, on the contrary, it is associated with these species, it attaches itself to them and develops and fruits abundantly.

To test Brefeld's observation, we traced the result of the cell-culture in a drop of orange juice of a single reproductive body. It measured ·0035 mm. ; six to eight hours after it was sown a large crack formed in its external membrane, and a bluish spherical spore escaped. The empty membrane is often hyaline, slightly greyish, and sometimes finely granular; it is thinner than in *Ch. Jonesii*, and soon undergoes solution in the liquid. The existence of this membrane from which the spore escapes in germination proves that the reproductive body must be regarded as a monosporic sporangium, and not, as Brefeld thought, as a spore.

The spore now swells to many times its original size, while still remaining spherical, and puts out one or two hyphæ, which elongate, ramifying in a fan-like manner. The branches are at first destitute of lateral ramifications, but later they develop as they lengthen lateral protuberances and, subsequently, short and hooked branches, which are simple or again ramified. These lateral processes are quite different from the radicular filaments of the mycelial filaments of *Mucor;* they are never, like those, separated from the principal hypha by a basal partition (fig. 29). This production in germination of one or two elongated hyphæ, the branches

of which gradually diverge and are studded with hooked branchlets, gives a habit altogether different from that of *Ch. Jonesii*, and supplies, perhaps, the best proof of the specific difference of the two plants.

This diffuse mycelium, the offspring of a single spore, spreads itself in four days, little by little, through the whole drop, passes its borders, and extends over the covering-glass and covers a circular space 5-6 mm. in diameter. On the fourth day a few of the principal hyphæ exhibit a few transverse septa. The fifth day, the extremities of the hyphæ which occupy the periphery of the drop put out slender branches into the air of the cell. Occasionally, these aerial prolongations may be the ends of the hyphæ themselves, but more usually they are a development of one of the branches of a lateral process (figs. 30, 31). In this case the other branches of the process grow, and, becoming felted together, form a more or less complicated mass investing its base. On the sixth day a large number of these aerial filaments bear on lateral branches groups of bluish monosporic sporangia (figs. 30, 32).

Cultures of this kind often repeated prove that *Chætocladium Brefeldii* may be perfectly autonomous, and Brefeld's failure attributable to many causes, possibly amongst others to an unfavorable medium, is not conclusive.

When the spores of *Ch. Brefeldii* are mixed with those of *Mucor Mucedo*, wherever the apex of a branch of one of the lateral processes of a hypha of the former comes in contact with any part of a hypha of the latter, it forms an intimate attachment, and finally, by the absorption of the intervening walls a complete continuity between the branch and the hypha (figs. 33, 34). The other branches of the process immediately develope and form about the point of union a felted mass, more or less complicated. Some of them in different stages of development will be found from the second day after the sowing and indicate points of union between the two systems of mycelium.

Union of hyphæ may take place when only those of *Chætocladium* are concerned. Fig. 35 represents three spores s, s', s', of *Ch. Brefeldii*, which have generated side by side, and the hyphæ of which have fused, so that it is impossible to determine their points of union. Fig. 36 shows that two branches of a hypha have curved towards each other, forming a loop. This property of anastomosis of the mycelium which is possessed in so high a degree by *Ascomycetes*, *Penicillium*, *Botrytis*, *Arthrobotrys*, here appears for the first time amongst the *Mucorini*, al-

though we now know that others of the group also manifest it.

On the third day the *Mucor* produced fructification; the *Chætocladium* did not do so till it had developed in the air its long slender branching hyphæ. These generally originated from a mycelial tubercle or from a point adjacent to one, but much more frequently they were developed from the ordinary hyphæ of the *Chætocladium* remote from any point of union with the *Mucor;* on the other hand, many of the tubercles produced no aerial hyphæ at all. On the fourth day the aerial hyphæ developed branches with more or less complicated groups of sporangia, but always destitute of pointed terminations which only develope subsequently with increased vigour of growth. Whenever in the air within the cell the sporangiferous hyphæ of *Mucor* come into contact with the long flexuous hyphæ of *Chætocladium,* unions of the same kind are effected as occur in the case of those which are submerged.

These observations quite confirm all that Brefeld has stated, and it must be allowed that the *Chætocladium* attains by virtue of its parasitism a much more considerable development. *Chætocladium Brefeldii* is not a parasite in the absolute sense of the word, which would imply that parasitism is a necessity of its existence. Yet it undoubtedly possesses the power by forming unions with *Mucor* of appropriating nutriment from it. Yet we have cultivated the two plants together, without being able to detect any union between them.

The species of *Chætocladium* are then indifferently parasitic or not. Other species of *Mucorini* exhibit the same phenomena, in appearance so contradictory—one plant fixing itself upon another and drawing from it part of its nutriment, yet able at the same time to develope, live, and fructify autonomously. But perhaps, after all, this kind of ambiguous parasitism need not very much surprise us. In fact, all fungi, like all animals, are parasites in relation to chlorophyll-containing plants, from which ultimately they must needs draw their supply of carbon. Being then in the last resort parasitic we need not be astonished if the extent of their parasitism should in different cases be a little more or a little less marked.

Remarks *on the* Affinities *of* Rhabdopleura. By E. Ray Lankester, M.A. (With Woodcuts.)

The memoir of Mr. G. O. Sars, reproduced from his own English publication in the preceding pages, is of very great interest, in that it clearly makes known to us the anatomy of the remarkable genus established by Allman in this Journal, with so much shrewdness on the examination of a few spirit specimens. I desire to take this opportunity of pointing out that the supposed relation of *Rhabdopleura* to the Hydrozoa, supported above by Sars, is not really indicated by the facts he has adduced. There is, I venture to affirm, on the contrary, no important feature in which *Rhabdopleura* really approximates to the Hydrozoa. It is separated by a huge gulf from the Diploblastica, from the animals devoid of true body cavity, and possessing extensive gastric ramifications.

The real and great interest of *Rhabdopleura* seems to me to consist in this, that it tends to upset that classification which has been adopted by such distinguished investigators as Gegenbauer and Haeckel. These authorities remove the Polyzoa from association with the Mollusca, and place them in the central or proliferous ancestral group, Vermes. Huxley and Allman, on the other hand, remain staunch to Milne-Edwards' arrangement of the Polyzoa under the Molluscan sub-kingdom.

Though one class of the so-called Molluscoidea, namely, the Tunicata, has to be removed from the Molluscan family-tree in consequence of recent researches—if our classifications are to have any genealogical signification, and very few persons doubt that they must have such a signification—yet there really has not been a serious attempt to contravert those reasons which have been assigned, especially by Allman, for associating the Polyzoa with the Mollusca. In passing I may say that still less is there reason for removing the Brachiopoda from such association. In *Rhabdopleura* we have a form which binds the Polyzoa fast to the Molluscan series, and with the Polyzoa undoubtedly go the Brachiopoda, as the recent observations of Morse on the development of *Terebratulina*, and my own on *Terebratula vitrea*, show.

When it is once admitted, as it may be most fully, that the great family-tree of the Mollusca has developed directly from the Vermes, and *more largely than any other* of the four great trees springing from Vermian ancestors has retained the essential organization of its ancestors in a primitive

condition, then it ceases to be surprising that, with so much confidence, lowly developed or degraded groups of Mollusca are detached by systematists from the Molluscan tree, and referred back to the fundamental group of Worms.

There are three modifications of structure which are distinctive of the Mollusca, and are of significance in the order in which they are mentioned, viz. foot, gill, mantle-shell. They each have their representative, their homogen, in the commonest worms, but unspecialised, not elaborated in the Molluscan style. The foot is a muscular specialisation of the 'neural' or 'ventral' post-oral body-wall. It is the most characteristic of all Molluscan features. The gills, again, are lateral and post-oral diverticula of the body-wall, such as are found as respiratory organs in many Vermes. But in some classes of the Mollusca they have taken on special functions with accompanying changes of form and of apparent relations, which strangely obscure their origin. The mantle, with the calcareous matter to which it gives origin, is again fully represented in the tubicolous Annelids, and is, after all, a mere flap of the body-wall, which may be developed to an enormous extent or be absent altogether as well as the shell. At the same time the production of an embedded chitinous shell (pen of Cephalopoda, embryonic plug of Gasteropoda, ligament of Lamellibranchs), together with a superficial calcareous valve or valves, must have at a very early period of its branching off have become characteristic of the Molluscan pedigree.

There is a consideration of a general character, which relates to the probable effect of a long-continued process of evolution of organic forms, and is of the greatest importance in the examination of the Molluscan pedigree, as, indeed, in all such inquiries. That consideration is this, that the lowly organised forms which we at present see are *by no means necessarily*, though they are possibly, and often, no doubt, are actually, representatives of the lowly organised ancestry of the higher forms to which they are most nearly allied. They often, on the contrary, must be degraded forms, or forms which have progressed in the direction of simplification from a more highly elaborated or more 'typical' ancestry. Thus, very probably, both *Amphioxus* and the Ascidians do not indicate to us the direct way backwards from the Vertebrata to an invertebrate ancestry. They both very probably have become vastly modified and simplified in their own way, as compared with the ancestor common to them and the Vertebrata. Long ago Goethe perceived the tendency to substitute the order in which things become known to us for the order of

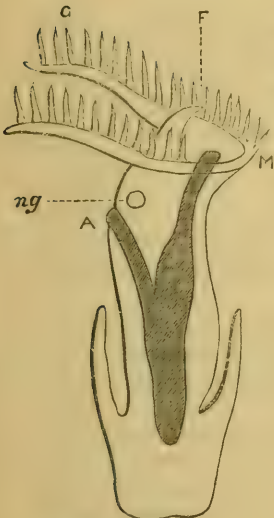


Fig 1

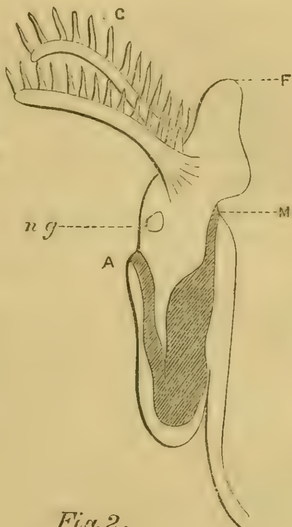


Fig. 2.

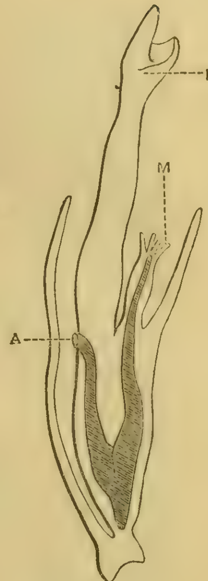


Fig. 5.

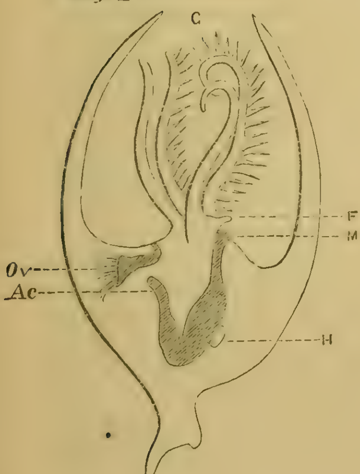


Fig. 3.

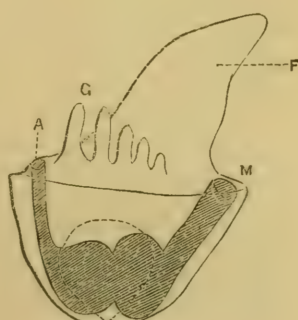


Fig. 4.

Explanation of the woodcuts, being a series of Acephalous Molluscs.

M. Mouth. A. Anus. Ac. Blind ending of intestine. F. Foot. G. Gill-tentacles. H. So-called heart of *Terebratula*. *ng*. Nerve-ganglion. Ov. Oviduct.

Fig. 1.—Hippocrepian Polyzoon. Fig. 2.—*Rhabdopleura*.
„ 3.—*Terebratula*. „ 4.—Young *Cyclas*.
„ 5.—*Dentalium*.

their true or causal relationships, when he said, "Was würden wir von einem Architecten sagen, der durch eine Seitenthüre in einen Palast gekommen wäre, und nun, bei Beschreibung und Darstellung eines solchen Gebäudes, alles auf diese erste untergeordnete seite beziehen wollte? Und doch geschieht dies in den Wissenschaften jeden Tag."

It is possible that in this way we may be led to look at the Mollusca through a side door, if we do not remember that the simplest forms referable to that group, known to us at this day, are not necessarily the most nearly representative of the Molluscan ancestry.

In *Rhabdopleura* we find a large and well-developed foot (the buccal shield), justifying the previous assumption that the epistoma of the fresh-water Polyzoa represents the foot of Mollusca.

In Brachiopoda there is even less trace of the foot than is afforded by the Polyzoan epistoma; but in *Terebratula* there is a bare indication of it—a so-called lower lip. Would it be right from this to conclude that the Brachiopoda are more nearly related to the Vermes, and that we have an ascending series from them, through the Hippocrepian Polyzoa to *Rhabdopleura*, and thence to Mollusca proper? It seems not; but far more probably we have a descending series—a loss of this powerful foot—accompanying the acquisition of *immobility* and subsequent arborescent stock-building.

With the assumption of these habits we have further the abortion of the cephalic region common to Polyzoa, Brachiopoda, and Lamellibranchs; and further, the huge development of the gill-tentacles—not as respiratory organs, for which function they are far larger than needful—but in all three classes as excitors of currents, by means of their cilia, bringing food to the mouth. The gill-tentacle of Rhabdopleura is even more like to an arm of Terebratula than to one side of a hippocrepian lophophore. Still more justly may it be compared in form and in relation to other parts with the gill-plume of some Gasteropods; whilst its relative position as regards foot, mouth and anus, is precisely that of the budding gill-laminæ of a young Lamellibranch.

In the accompanying woodcuts I have diagrammatically indicated these fundamental points of agreement among Acephalous Mollusca. The comparison of the Cephalophora with the Acephalous forms is rendered easy through the Chitons on the one hand and the Lamellibranchs on the other.

It has not been my object in the above few lines to discuss the details of Molluscan morphology, but to give what I believe

to be its true significance to this admirably worked-out form, *Rhabdopleura,* and that I conceive to depend upon the large development of that most Molluscan of organs, the "foot." The absence of a mantle-fold is of small significance, being paralleled in various Mollusca proper. The abortion of the cephalic region is characteristic of the whole branch of Acephala, and the same region suffers in *Dentalium,* and even in the Cephalopoda also, to the advantage of the evermore function-annexing foot.

RECENT RESEARCHES *in the* DIATOMACEÆ.
By REV. E. O'MEARA, A.M.[1]

VI.

IN the family *Achnantheæ* the valves are symmetrical in the longitudinal axis, but unsymmetrical in the plane of separation; the frustules are more or less geniculate, so that of the valves one is concave while the other is convex; the former only possesses a central nodule. The genera *Achnanthidium* and *Cocconeis* agree in these general characteristics, but are separated into a distinct family, the *Cocconeideæ,* for reasons that shall be hereafter assigned, so that the family *Achnantheæ* embraces the solitary genus *Achnanthes.* The two species of this genus which have been observed abundantly in a living state, *A. brevipes* and *A. subsessilis,* correspond with the *Naviculeæ* in the structure of the cell-contents, inasmuch as they possess a middle granular plasm-mass and two endochrome-plates lying on the girdle-bands, and thence passing over the valves. The endochrome-plates exhibit a slit in the middle, and separate by an incision proceeding from the ends. The well-defined nucleus lies always nearer to the concave than to convex valve. In the few specimens of *A. longipes* which came under Dr. Pfitzer's notice, the endochrome-plates were split up into numerous small pieces; but whether this be the normal condition or not remains to be determined.

The marine *A. longipes* was observed by Smith in the act of forming auxospores, the same form, as well as *A. subsessilis,* by Lüders. In respect to the former Smith maintained that a single cell forms two auxospores, Lüders supposed that two cells co-operate to produce the same result; while in the case of *A. subsessilis* a single mother-cell gives birth to a single auxospore. In both cases, according to Lüders, the cell-

[1] Continued from Vol. XIII, p. 15.

contents divide and afterwards re-unite, alternately in the case of *A. longipes,* directly in that of *A. subsessilis.* According to Lüders, there is always found a gelatinous sheath surrounding the infant cells, which force themselves out by an opening at the end.

It appears confusing that two species so nearly related should exhibit such different conditions in the formation of their spores, and therefore the author expresses a wish that observers residing near the sea-shore will carefully examine fresh specimens with a view to ascertain satisfactorily the process of spore-formation.

After the *Achnanthideæ* Pfitzer ranges the group *Cocconeideæ,* in which are embraced the two genera, *Achnanthidium* and *Cocconeis. Achnanthidium* has been distinguished from *Achnanthes* by the fact that while the latter is stipitate the former is free. To this Pfitzer adds another mark of distinction founded on the character of the endochrome-plates. *Achnanthes* has two endochrome-plates, while in *Achnanthidium lanceolatum* there is but one, which lies upon the convex valve. This peculiarity places *Achnanthidium* in intimate relationship with the next genus, *Cocconeis. Cocconeis Pediculus* at least possesses a single endochrome-plate, occupying a position similar to that of *Achnanthidium lanceolatum,* split up on the edge, and with its scallops reaching the girdle-band. It exhibits also a strong slit on one side, a circumstance which in the author's opinion shows that the *Cocconeideæ* are not decidedly symmetrical in the longitudinal plane. This feature discovers itself in *Achnanthidium* likewise, in the structure of the concave valve, by a stronger development of the central nodule on one side than on the other. The endochrome-plate is more deeply scalloped in proportion as the valve is large. The central incision sometimes extends so far as to effect a complete division of the plate. A nucleus is clearly seen in *Cocconeis Pediculus,* as is also a central accumulation of plasm. So the *Cocconeideæ* are essentially distinct from the *Naviculeæ,* and exhibit a decided analogy to the similarly epiphytic *Amphoreæ,* inasmuch as in neither does the occurrence of the longitudinal line exhibit anything to correspond with it in the structure of the primordial cell. In the *Amphoreæ* and *Cocconeideæ* the endochrome-plate stands related to the surface of attachment. The former attaches itself by one girdle-band, and upon this plane lies the middle of the plate; the latter are fixed to foreign bodies by one valve, on which the middle of the plate lies. As respects the formation of auxospores, in *Achnanthidium* it has never been discovered, but in

Cocconeis frequently. Carter first found that two cells secrete a gelatinous envelope, open, and by a true act of copulation construct a single spore, which is first globular, then becomes ellipsoid, and finally separates into two longitudinal portions, each of which is an auxospore. On the contrary, Smith maintained that a single cell pours out its contents, and therefrom developes a single spore; but the author adds that while Carter's observations refer to *Cocconeis Pediculus*, Smith refers to what he calls the nearly allied species, *Cocconeis Placentula.* Lüders agrees in this point with Carter, and Dr. Pfitzer confirms their position in regard to *C. Pediculus.* The following differences are noticeable. One supposes the separation has been completed within the envelope, the other not till it has been thrown off. According to Carter the firstling-cells turn the concave sides one to the other; according to Lüders they are parallel. Dr. Pfitzer observes that the material at his command was too young to enable him to decide this question.

Gomphonemeæ.

In this are included three genera—1. *Sphenella*; 2. *Gomphonema*; 3. *Rhoicosphenia.* They are distinguishable by the fact that in the general structure of the valves they resemble the *Naviculeæ.* Like the latter, the frustules possess three nodules on each side, and two median-lines divided into two parts by the central nodule. Still they are unsymmetrically constructed, the upper end being broader than the lower. As the *Achnantheæ* exhibit a want of symmetry in the axis of separation, and the *Cymbelleæ* in the longitudinal axis, the *Gomphonemeæ* are unsymmetrical in the transverse axis· The two last-named groups are more closely related than has been hitherto believed both in respect to the structure of their valves and also of their cell-contents. On the one side the *Cymbelleæ* so far as they are stipitate show a distinction between the upper and under ends, which is not noticeable in the case of valves exposed to the action of heat or in the free-living forms; and on the other side the *Gomphonemeæ* are unsymmetrical not only in the transverse axis, as was before stated, but also in the longitudinal axis. In all, this feature manifests itself in the structure of the primordial cell; in some, in the structure of the valve itself. In *Sphenella vulgaris*, Kütz., the valves are noticeably more decidedly convex on one side than on the other; and in other cases in which the margin of the valve appears symmetrical, the sculpture on the two sides of the longitudinal line is different. Tuffen West's delineation of *Gomphonema geminatum* in

Smith exhibits on one side of the central nodule a group of four or five separate depressions which do not occur on the other side; and this is a regular occurrence. Besides, the median lines at the central nodule and the under end-nodule bend toward the same side—namely, that in which the above-mentioned depressions occur, and which are situated in a well-defined area. At the upper-end nodule the median line at first takes the same bend as at the other nodules, but afterwards changes round to the opposite side, towards a small space in which no depressions occur. These peculiarities render manifest the unsymmetrical character of the valves. In many specimens the median line is bowed, however slightly, so as to present its concave side to the group of depressions. In addition it is important to observe that where these depressions lie to the right on the upper valve, they are found also on the right in the underlying valve. So that the *Gomphonemeæ* are not diagonally constructed as the *Pinnulariæ* are, but unsymmetrically on the homologous sides, like *Anomoeoneis* and the *Cymbelleæ*. The structure of the primordial cell corresponds: there is but one plasm-band situated on the cell wall; only one endochrome-plate occurs; but while the former and the middle of the latter in the *Cymbelleæ* lie on the more strongly-arched, we find them in the somewhat unsymmetrical *Gomphonemeæ* (*e.g.*, in *Sphenella vulgaris*) on the less convex girdle-band. The central plasm-mass is not so broad on the one side as it is on the other, on which lies the nucleus and the turned-up edges of the endochrome-plate, this is also the case in the greater number of the *Cymbelleæ*. The endochrome-plate has the same structure as in the last named, although its position differs to the extent of 180 degrees. The division of the endochrome-plate proceeds by an incision from the ends. The free edge grows across the valve until the original position has been reached. A transverse section of the *Gomphonema*-cell would more clearly represent the relative position of the parts.

The genera *Gomphonema* and *Sphenella* are distinguished from one another only by the circumstance that the frustules in the former are stipitate, and non-stipitate in the latter, which Pfitzer, following Grunow and Rabenhorst, considers an inadequate generic distinction, for this reason, that the stipitate forms occur free and with active motion. As respect the substance of the stipes, it appears in this instance, as in the case of *Cocconema* and *Brebissonia*, in its early stage as a simple, colourless, well-defined gelatinous band; but in its more advanced stage of growth it presents a brownish central thread, surrounded by a broad, colourless investment.

As regards the construction of auxospores, Thwaites informs us that in this genus, as well as that of *Cymbella*, two mother-cells develope two auxospores lying parallel to them. Thwaites made this observation in the case of a species related to *Gomphonema dichotomum*, Sm., in *G. dichotomum*, *G. tenellum*, *G. olivaceum*; Pfitzer, in the last-named species. An actual union of the two primordial mother-cells does not occur, but only a diffusing of the contents through the gelatinous investment. When the auxospores have nearly reached their definitive length they develope a fine membrane, within which the valves are formed one after the other. They are at first strongly arched and bent on the longitudinal axis; the striation developes itself clearly in a direction proceeding from the centre towards the ends. The firstling-cells at first have girdle-bands as narrow as those in *Navicula*, the outer larger valve, even in its earlier stage, embracing the smaller inner valve. After the second division, out of the bent-valved firstling-cells spring normal cells with two straight valves, just as in the case of *Navicula*. The plane of separation in the firstling-cell is at a right angle to that of the mother-cell from which it has sprung—the valves of the former being seen when the girdle-band of the latter is turned towards the observer.

Rhoicosphenia.

This may be regarded as a *Gomphonema* unsymmetrical in its three dimensions. In addition to the want of symmetry in the longitudinal and transverse axis, there occurs in this genus a bending in the plane of separation, and also an unsimilarity of the two valves, of which one only—namely, the concave—possesses a central nodule; besides, the fillets which occur on the upper end of *Gomphonema* are here most strongly developed. In the primordial cell no remarkable distinction is found compared with *Gomphonema*; but it is far otherwise with *Achnanthes*, *Achnanthidium*, and *Cocconeis*, to which genera Grunow and Rabenhorst attached it. *Rhoicosphenia curvata* (Kütz.), Grun., and *R. marina* (Kütz.), possess a single endochrome-plate, the middle line of which lies on the plane of one girdle-band, covering the two valves, and even folding itself over upon the other girdle-band. Viewed in this aspect it appears broken into four parts, the division between two of these parts being observable on the F.V. Normally this occurs in a *Rhoicosphenia* lying on one valve on the same side of the upper and under valve. The middle portion of the valves is for the most part covered with endochrome, which is not the case in *Gomphonema*. A

slight indentation is observable at the ends of the plate, in which there is an approach to the *Cocconeideæ*, similarly geniculated in the axis of division. The division of the endochrome plate proceeds just as in the case of *Gomphonema*, towards which genus many transition-forms from *Rhoicosphenia* tend.

The formation of auxospores was observed by Thwaites in the case of *R. curvata* so early as 1847. This process goes on precisely as in *Gomphonema*, only the plasm-sac, according to Thwaites, does not emerge at the side, but from an opening at the end of the cell. Smith found the same species as well as *R. marina* in conjugation. In the case of the form last-named, Lüders has added the remark that the auxospores before they have attained the length of the older cells are invested with a very fine silicious coating, which exhibits broad transverse striæ. This investment is at first cylindrical, but becomes bent in the firstling-cells, which issue from it.

VII.

The forms embraced in the four groups to be now considered are placed by Dr. Pfitzer, in reference to themselves and to other groups, in a relationship very different from that assigned to them by most writers of authority on the subject. The groups referred to are *Amphipleureæ*, *Plagiotropideæ*, *Amphitropideæ*, and *Nitzschieæ*. Heiberg indeed places the genus *Amphipleura* under that of *Nitzschia*, and that because the species of the former family, which he had specially examined, was that named by Smith *A. sigmoidea*—a form which I believe to be identical with *Nitschia sigmoidea*. So under the supposition that the form named is to be properly regarded as really belonging to the genus *Amphipleura*, he was quite right in the position he assigned to it; but regarding *Amphipleura pellucida* as a genuine type of the family, its position, according to Heiberg's system of classification, is widely apart. Grunow at first placed *Amphipleura* among the *Surirelleæ*, but afterwards made it the type of a distinct group, in which he included *Berkeleya*. Pfitzer agrees with Grunow as to the comprehension of *Berkeleya* in the group, though he places the group itself in a very different relation. The position of *Amphipleura*, according to Ralfs, is between the *Nitzschieæ* and *Surirelleæ*. Rabenhorst placed it under the *Naviculaceæ* in his Süssw. Diat., but subsequently, in Fl. Eur. Alg., ranges it between the *Synedreæ* and *Nitzschieæ*.

According to Kützing, William Smith, and Professor H. L. Smith, *Amphipleura* is assigned to a position more or less intimately associated with the *Naviculaceæ*.

The two next groups, *Plagiotropideæ* and *Amphitropideæ*, are intimately associated with the genus *Amphiprora*, Ehr., which has been regarded as nearly related to the *Naviculaceæ*, but the allied forms are by Pfitzer associated with the *Nitzschieæ*. The character which these four groups possess in common, and in consequence of which they are so intimately associated by that author, is the development of certain longitudinal lines into more or less prominent keels. Whether this characteristic should be deemed a sufficient reason to justify the arrangement referred to may be considered as liable to doubt; it is, however, important to keep this common feature in view.

Let the author now speak for himself—

Amphipleureæ, Grun.

This embraces two genera, *Amphipleura*, Kütz., and *Berkeleya*, Grev. The only European fresh-water form of this group, distinguished from the *Naviculeæ* by the development of the central nodule on one longitudinal line, and the three keels of the valve—namely, *Amphipleura pellucida* (Ehr.) Kütz.—possesses two endochrome-plates lying on the girdle-bands. A central plasm-mass is also observable. In the process of constructing auxospores, only *Berkeleya Dillwynii* (Ag.), Grun., has been observed by Lüders. For this purpose many cells unite in a common gelatinous envelopment on the extremities of the tubes, or smaller expansions arise on the sides and middle of the tubes; two mother cells then develope two auxospores.

"The structures described by Kützing, Bac., p. 112, t. 23, f. ii, 2 a b c, as the fruit of *Berkeleya tenuis* (Kütz.), appear to me," adds Pfitzer, "not to belong to the *Bacillariaceæ* at all." It appears then that, so far as the internal structure of the cell is concerned, *Amphipleura* bears a strong resemblance to *Navicula*.

In case the character noted by Pfitzer—namely, the development of a central nodule on one median line, by which I understand its occurrence on one valve and not on the other—be sustained by fact, the position of *Amphipleura* will be seriously affected. In special reference to this subject I have examined very many specimens of *Amphipleura pellucida* and could observe no trace in any of a central nodule.

Plagiotropideæ.

This embraces only one genus, *Plagiotropis*, gen. nov. The development of the median lines into prominent keels, which in the preceding group occurred to a slight extent, is more strongly marked in the two to be next treated, in which the six nodules appear again in the normal manner. The only species to be here assigned which occurred to the author in a living state was found in brackish water in the harbour of Pillau, and is distinguished from the next related genus, *Amphiprora* (Ehr.), by the position of the keel, which, instead of being central, is strongly excentric; and also by the disappearance of the prominent longitudinal striæ, which along with the same occur in all the *Amphiproreæ*. The valve of *P. baltica* is sharply lanceolate in outline, resembling *Navicula serians* (Kütz.), in breadth from one-fifth to one-sixth of its length; the keel describing a gentle curve, not sigmoid, but, as in the *Amphiproreæ*, sinking down at the central nodule to the plane of the valve which it divides into two parts in the proportion of one to four, so that it is very excentric. Supposing the *Plagiotropis* to lie so as to present its valve-surface to the observer, on the upper valve the keel deviates towards the right, on the under-valve towards the left, so that *Plagiotropis*, like *Pinnularia*, is diagonally constructed. The valves exhibit a very fine striation, and when dry are nearly colourless. The girdle-band view strongly resembles that of an *Amphiprora*, pretty much that of *Amphiprora indica* (Grun.), only that the two keels obviously lie in different planes. The inner structure is similar to that of *Navicula*. Two endochrome-plates lie upon the girdle-bands, and thence with their edges stretch to some extent over the valves. Each plate covers the greater part of the valve from the keel of which it has extended, the opposite margin going a shorter distance towards the other keel. The structure of the soft parts corresponds with the diagonal construction of the cell-cover.

Amphitropideæ.

In this group we have only a single form—*Amphitropis paludosa* (Rab.), quere *Amphicampa paludosa*, Rab. Fl. Eur. Alg., p. 257. The *Amphitropideæ*, says Pfitzer, are related to the *Plagiotropideæ* somewhat as the *Cymbelleæ*, still symmetrical in outline, are to the *Naviculeæ*. The form of the cell-cover differs little, but the inner structure is quite different. The *Amphitropis paludosa* (W. Sm.) Rab., is distinguished by means of its sigmoid keels, constructed in

relation to one another, as in the case of *Scoliopleura*, as also by the two accompanying longitudinal striæ. It has only a single endochrome-plate, lying on one girdle-band, and with its margins reaching to the valves; fission takes place from the ends throughout. A central plasm-mass is obvious. Whether the similarly keeled genera, *Amphiprora* (Ehr.) and *Donkinia* (Pritch.), belong to this or to the preceding group remains to be determined. Auxospores in all these forms are still unknown. The concluding observation of our author suggests the propriety of subjecting the various related forms to a careful examination, with a view to a satisfactory arrangement.

Nitzschieæ (Grun.).

The forms hitherto treated of agree in this particular, that, with the exception of the *Epithemieæ*, which have a very indistinct median line, they exhibit nodules and distinct median lines; and that the transverse section is rectangular or trapezoid, except *Encyonema*, in which case it is slightly rhomboid. The *Nitzschieæ*, on the contrary, possess neither nodules nor median lines, and besides, their transverse section is ever distinctly rhomboid. This group embraces three genera, *Nitzschia*, *Ceratoneis*, and *Bacillaria*.

Nitzschia.

In which we have species of a twofold structure, which may be distinguished as similarly striate (gleichriefige) and alternately striate (wechselriefige). The valves of every *Nitzschia* exhibit on one margin a row of nodulated thickenings, called keel-puncta, which are situated in the two valves either on the same or on opposite sides. All the *Nitzschieæ* examined possess a central granular plasm-mass, in which a large nucleus may be distinguished, as also a single endochrome-plate, either completely interrupted in the middle, or nearly so by an elliptical opening.

The endochrome-plate in the case of the similarly striate *Nitzschieæ*, so far as the author has been able to investigate (*N. elongata* (Hantzsch), *N. flexa* (Schum.), lies on one girdle-band, and that the one which stands more remote from the keel-puncta; it then covers the valve, and with small folds extends to the opposite girdle-band. Some of the alternately striate *Nitzschieæ*—for example, *N. palea* (Kütz.), W. Sm., *N. sigmoidea*, W. Sm., *N. Clausii*, Hantzsch —present the same position of the endochrome-plate, while *N. dubia*, Hantzsch, and *N. linearis* (Ag.), W. Sm., differ widely in the inner structure. In them the endochrome-

plate passes freely across the cell, reaching from one row of keel-puncta to the other. When the frustule so stands as that the keels are to the eye of the observer super-imposed one on the other, a narrow dark brown longitudinal band appears between two broad colourless ones. If, again, the frustule lies on one obtuse-angled edge, it appears entirely light yellow-brown. And again, if the frustule or one girdle-band lie parallel to the slip on which the object lies, the colouring of the cell, which would naturally be white, is of a somewhat darker hue, because the endochrome-plate will be projected in a direction inclined to the plane of its acute-angled side.

We have consequently among the *Nitzchieæ* species with the inner and outer structure symmetrically diagonal, some having the silicious envelope and the soft inner parts unsymmetrical to one another on the homologous sides; and lastly, intermediate forms in which the silicious envelope is diagonal, and the inner structure unsymmetrical to it on the homologous sides. The cell-division has been followed out in *Nitzschia elongata* and *N. sigmoidea.* It commences with a longitudinal division of the endochrome-plate from the ends throughout, then the nucleus separates into two, and the division of the plasm ensues. The daughter-cells at first lie in the longitudinal axis of the cell, and then after a time assume their natural position.

Ceratoneis, Ehr.

The minute forms, *C. acicularis* (Kütz.), Pritch., and *C. reversa* (W. Sm.), Pritch., as regards their inner structure differ in no respect from the normal *Nitzschieæ,* with a single endochrome-plate lying on one girdle-band; but on the contrary, *C. longissima* (Brib.), Pritch., exhibits numerous minute plates.

Bacillaria.

The single cells of *Bacillaria paradoxa,* Gmel., have likewise a single endochrome-plate covering one girdle-band; nevertheless in the greater number of the cells of a colony the endochrome-plate appears separated into two through means of division. As respects the development of auxospores in the *Nitzschieæ,* we know only this, that Schuman found a form belonging to *Nitzschia* with zone-covers (zonenkleide). In addition to the coarse dark zones, there was present also a system of fine longitudinal lines on the sheath.

It is to be regretted that Dr. Pfitzer should have given the authority of his justly-distinguished name to the revival

of the Ehrenbergian genus, *Ceratoneis*, for the purpose of separating the forms embraced under it from the genus *Nitzschia*, to which they belong. Grunow has well described Ehrenberg's genus, *Ceratoneis*, as a medley of heterogeneous forms, and retained the generic name to receive the single species = *Eunotia arcus*, W. Sm., in which he is followed by Professor H. L. Smith. There may indeed be good reason for retaining the generic name so limited, but strong objections may be urged against the genus as Ehrenberg and Kützing left it. Too much praise cannot be given to Dr. Pfitzer for his observations on the genus *Nitzschia*. No doubt the forms investigated by him constitute but a small proportion of those comprehended under this extensive family; but the structural characters he has illustrated, in such as he has examined, may serve as a clue to further investigations, and can scarcely fail to lead to satisfactory results.—[*From the* 'Journal of Botany.']

The Lymph Spaces *in* Fasciæ; *a* New Method *of* Injection. By H. P. Bowditch, M.D., Assistant Professor of Physiology in Harvard University.[1]

The lymph spaces existing between the tendinous fibres of fasciæ, and the connection of these spaces with lymphatic vessels, have been well described and figured by Ludwig and Schweigger-Seidel in their monograph on this subject.[2]

The researches of Dr. Genersich[3] have shown that the fasciæ, in virtue of this structure, play a very important part in keeping up the flow of lymph through the lymphatic vessels. His first experiment was as follows:—A piece of fascia was removed from the leg of a dog, and tied over the mouth of a small glass funnel with the inner side (*i. e.* the side next to the muscles) uppermost. A few drops of a turpentine solution of the extract of alcanna root were then placed upon this surface, and the fascia alternately stretched and relaxed by partially exhausting the air from the funnel and letting it return again. In this way the colouring matter was made to penetrate into the spaces between the fibres of the fascia, and to enter the lymph vessels on the opposite side. The same result was obtained when the colouring matter was injected between the muscle and the

[1] Reprinted from the 'Proceedings of the American Academy of Arts and Sciences,' Feb. 11th, 1873.

[2] 'Die Lymphgefässe der Fascien und Sehnen.' Leipzig, 1863.

[3] 'Arbeiten aus der Physiologischen Anstalt zu Leipzig.' V. Jahrgang, p. 53.

fascia, and the latter stretched and relaxed by passive movements of the limb. Experiments on animals where the flow of lymph through the thoracic duct was measured showed that passive movements of the limbs increased this flow in a very striking manner. Galvanization of the muscles had a similar but less powerful effect.

The alternate widening and narrowing of the lymph spaces between the tendinous fibres seems therefore to cause the absorption of the lymph from the neighbouring parts as well as its onward flow into the lymph vessels, the valves in these latter preventing, of course, a flow in the opposite direction.

In this function of the fasciæ we may perhaps find an explanation of the success of the Swedish movement-cure and of all methods of treatment which involve passive movements of the limbs, the removal of effete matters from the tissues being favoured by an increased flow of lymph.

The turpentine solution of alcannine has several advantages for the injection of lymph spaces. Since turpentine does not mix with water, there is no possibility of the colouring matter being diffused by imbibition through the tissues, and thus obscuring the anatomical relations of the parts. The same immiscibility prevents also all swelling or shrinking of the tissues as a consequence of the injection. This is always to be feared when watery or alcoholic fluids are used.

A very good method of injecting the lymph spaces is as follows:—Let a piece of fascia, carefully freed from loose connective tissue, be stretched somewhat tightly over the neck of a bottle. The point of a hypodermic syringe filled with the turpentine solution must be then passed obliquely into the fascia, care being taken that the point does not penetrate entirely through. If the fluid is then forced from the syringe, it will pass for a short distance into the lymph spaces, but a large portion of it will form a sort of extravasation in the neighbourhood of the point of injection. Several such partial injections may be made near the border of the piece of fascia, which must then be allowed to dry, still stretched upon the neck of the bottle. In drying, the tendinous fibres seem to shrink together, causing a dilatation of the spaces between them, in consequence of which the extravasated fluid is sucked onwards into the finest lymph spaces. In this way two, three, or even four layers of lymph spaces lying between as many different layers of tendinous fibres may be clearly demonstrated. The dried fascia may be mounted in Canada balsam between glass plates,

REVIEW.

Natural History of the British Diatomaceæ. By ARTHUR SCOTT DONKIN. M.D. Part III. Van Voorst.

AFTER an interval of two years the second part of the 'Natural History of the British Diatomaceæ,' by Arthur Scott Donkin, M.D., has been followed by the third, the letter-press in all respects such as might be expected from the publisher, Van Voorst, and the plates, although not equal to those the readers of the 'Quarterly Journal of Microscopical Science' were accustomed to from the exquisite pencil of the late Dr. Greville, are still fairly executed.

A great deal of useless and confusing nomenclature has been advantageously discarded by the author, as an exemplification of which the synonymy of *N. limosa* may be referred to. Some few matters there are which require special notice. *Stauroneis pulchella* has been removed from the genus *Stauroneis*, and placed under the genus *Navicula*, under the name of *Navicula aspera.*

This raises the question whether the genus *Stauroneis* might not be altogether abandoned. The characteristic is the lateral expansion of the central nodule, so as to form what has been designated a stauros. There is no species in which this character is more marked than in that under consideration; and if this, notwithstanding, be removed to the genus *Navicula,* there seems no valid reason why the other species of the old genus *Stauroneis* should not be similarly treated. Following Rabenhorst, Dr. Donkin has identified *Pinnularia Johnsonii*, W. Sm., with *Navicula scopulorum,* Bréb., and *N. mesotyla,* Ehr. The two latter, judging from the figures, are probably identical, but if Rabenhorst's description of the former be correct, "gegen die gerundeten enden Verlaufend," it can scarcely be regarded as identical with *P. Johnsonii,* the ends of which are expanded, as accurately described in the figures of Smith and Donkin.

Amphiprora constricta, Ehr., has been removed from the genus to which it has hitherto been assigned, and included in the genus *Navicula,* under the name of *Navicula simulans.* Smith's description represents this form as more symmetrical than it is in reality. The characters of the genus *Amphi-*

prora are certainly not so strongly marked in this species as in others, but in the specimens I have noticed the connecting membrane is slightly diagonal, the lobes of the valve do not lie in the same plane, nor is the central nodule of the upper valve exactly superimposed on that of the under one. Comparing the figure of *Navicula simulans*, both on the side and front views, with Smith's figure of *Amphiprora constricta*, I am disposed to doubt the identity, and to suppose that Donkin's form is a new species.

Pinnularia Pandura, Bréb., has been correctly identified with *Navicula Crabro*, Ehr., and *N. nitida*, Greg., as well as *N. didyma*, var. *costata*, Greg., reduced to the same species of which, at best, they are but varieties. The description of the species is exactly as it appears under a low power; striæ interrupted by a straight longitudinal groove into a broad outer and a narrow inner section, the latter consisting of a longitudinal row of conspicuous hemispherical dots; with a higher power the striæ are traceable down through the groove and emerge again, the extremities appearing as an elevated ridge along the median line.

Dr. Donkin has greatly contributed to a more satisfactory definition of the constricted forms of *Navicula*. Here there has been great confusion, and though something more remains to be done, there will henceforth be no difficulty in recognising *N. Apis*, *N. Bombus*, *N. interrupta*, not to mention others.

EUGENE O'MEARA.

QUARTERLY CHRONICLE OF MICROSCOPICAL SCIENCE.

MICROZOOLOGY AND EMBRYOLOGY.

New Observations on Infusoria.—O. Bütschli, in 'Schultze's Archiv,' vol. ix, 4th part, 1873, has an interesting and important series of notes on the organization and reproduction of Infusoria. He has studied species of Paramæcium and Amphileptus as to the question of sexual reproduction. He points out that there is no sufficient evidence to warrant the view which has practically passed into a common-place of zoological teaching—that the striated body seen both by Stein and Balbiani is a testicle. He denies that there is reason to hold that this fibrillated body breaks up into filaments, or that if it does that these filaments should be considered to be spermatozoa. There is no evidence that they pass over to the nucleus and fertilise it in the way assumed either by Balbiani or Stein. Again, he is not satisfied as to the nature of the viviparously produced acinetiform young said to be developed from the nucleus. He failed to find them in a long series of observations on Paramæcium, and thinks it still possible that they are parasitic, or, at any rate, not the normal development of the ripe nucleus. The structure of the nucleus he describes in several cases, and fully demonstrates for it—in the ripe condition—a multicellular structure. The nucleolus never presented any trace of a finer structure—and Bütschli seems inclined to regard the striated capsular bodies (testes of Balbiani, Stein, and others), not as metamorphosed nucleoli, but as parts of the altered nucleus, the signification of which is not understood. There is, no doubt, much justice in the position taken up by Bütschli, and his critical notes and observations cannot fail to excite new inquiry. Is it too much to hope that English microscopists will do some serious work in this matter?

Bütschli further notes the occurrence of an amyloid substance in *Gregarina Blattarum*, in *Nyctotheres* which accompanies it, and in a marine Infusorian—*Strombidium sulcatum*.

He also gives a minute account and figure of the structure of the trichocysts in an Infusorian *Polykrikos Schwartzii*. From this there remains no possibility of regarding the

trichocysts as anything but identical with the nematocysts of Cœlenterata. Bütschli argues that their occurrence is no reason for doubting that the Infusorian body is of unicellular character, since we may compare a single ectodermal cell of Hydra with a single Infusorian, and we find that nematocysts have the same relations to the protoplasm in both cases, developing in Hydra as in an Infusor, simply in the protoplasm, independently of the nucleus, and independently of anything like cellular elements. In fact, the nematocysts of both Infusoria and Hydrozoa are striking examples of the great generalisation, that the phenomena of life, whether exhibited in the building up of structure or in the transformation of energy, are solely dependent on the life-stuff—protoplasm—and that the corpuscular or cellular condition of that life-stuff is a secondary accident.

A new Infusorian, Wagneria cylindroconica.—In the first part of vol. x of 'Schultze's Archiv' Wladimir Alenitzen describes a new Infusorian under the above name. The interest of this form, which was found in the mud of the Newa, consists in its presenting the two circlets of cilia characteristic of the Vorticellidan *Trichodina*, &c., whilst at the same time its pharynx and a little capitular prominence, together with the position of the contractile vesicle, render it similar to such genera as *Prorodon* and *Lacrymaria.*

The Morphology of the Infusoria.—Professor Haeckel, in the 'Jenaische Zeitschrift,' vol. vii, part 4, 1873, discusses in his clear methodical style the question of the unicellular nature of the Infusoria. Both he and Gegenbauer have been inclined at one time to regard the ciliate Infusoria as disguised multicellular organisms. Haeckel, however, now gives in fully his adhesion to the view that they present nothing comparable to cell-differentiation. He gives a history of the views which have been held on the matter, and now demonstrates, from the known facts of the development of the Infusoria, that they are units of the first order of aggregation—simple corpuscles of protoplasm, and not multiples of such corpuscles. The whole morphology of the class is passed in review, and the various structures and organs presented by Infusoria are put in their true light. Finally, a revision of the classification of the Protozoa is given.

New Shell-bearing, Surface-swimming, Marine Infusoria.—In a second chapter of the same paper Haeckel describes very curious and beautiful forms of ciliate Infusoria, which come nearest to the genus *Tintinnus* of Claparède and Lachmann. Haeckel forms two families for them in the order

Peritricha, viz. Dictiocystida, and Codonellida. *Dictyocysta* has a fenestrated siliceous cell exactly like that of a Radiolarian, of the Cystidan group, but the animal which hangs from this basket is a ciliate Infusorian with large cilia on the peristome. *Codonella* has a more delicate bell-like shell and a very curious structure of the peristome. Nucleus and vacuoles are figured in it. The species of these genera were observed by Haeckel at Messina in 1859 and 1860, and others at Lanzarote in 1866 and 1867. The species of *Tintinnus* and *Tintinnopsis* described by Claparède and Lachmann are representatives of the same interesting families. We might most nearly, perhaps, indicate the condition of these Infusoria to the reader by comparing them to a *Cothurnia* or *Vaginicola* whose sheath has become detached from its support, so that the animal now swims hanging from the sheath like the tongue of a bell.

A new Amœboid Organism from Fresh Water, Pelomyxa palustris.—In the same number of the same journal Dr. Richard Greef, of Marburg, describes at length the very interesting amœboid organism which he was known to have under observation, and for which he some time since proposed the name *Pelobius*. This name was intended as a pair to *Bathybius*, but has to be abandoned since it is in use for an insect, and, moreover, the similarities between *Pelomyxa* and the structure known as *Bathybius* are not so close as Greef at one time supposed. *Pelomyxa* is figured in three plates, and, as its discoverer remarks, has great similarity to the *plasmodium* of some Myxomycetes, which it may very possibly prove actually to be. It has been found in old ponds at Popplesdorf, near Bonn, and also more recently near Marburg. The amœboid masses are large, often dark brown in colour, protruding lobose hyaline pseudopodia. The ground substance contains numerous nuclei, hyaline, homogeneous, highly refractive bodies, and delicate rod-like bodies. Under certain conditions the *Pelomyxa* mass gives rise to large swarms of minute Amœbæ, which Greef followed in some cases to a flagellate, freely-swimming condition. Greef regards *Pelomyxa* as a multicellular, or, rather, multinuclear amœboid organism, allied to the Myxomycetes, but to be classed under the Rhizopoda.

News of Bathybius.—The reference which Greef makes in his paper to *Bathybius*, and the continual references in zoological writings to that profoundly interesting structure, makes it desirable to record the latest information which has come to hand bearing upon that supposed organism. It must be remembered that the Bathybius of to-day is not Huxley's

Bathybius, but Haeckel's. Professor Huxley suggested the association of the coccoliths and coccospheres with the albuminoid slime which he clearly demonstrated to exist in specimens of Atlantic ooze, and which gives to that ooze a peculiar glairy character. Professor Haeckel removed the coccoliths from association with this albuminous material, showing that they were either formed in a Radiolarian frequenting the surface, *or* were independent surface-organisms taken in as food *near the surface* by that Radiolarian. There remained, then, the albuminous ooze-cement, which Professor Haeckel still considered as a definite organism, and of which he gave some drawings in the form of networks derived from the study of Atlantic ooze preserved in alcohol. No one would certainly be more willing to admit than both Professor Huxley and Professor Haeckel, that *Bathybius* now became a very suggestive subject for investigation, but could not be admitted as a satisfactorily established independent organism. The deep-sea explorations of the Lightning and Porcupine brought no news of *Bathybius*. To establish its claim, what was obviously necessary was the observation of it in fresh ooze, in the living state. Professor Wyville Thomson, in his 'Depths of the Sea,' is exceedingly cautious in dealing with *Bathybius*. He gives a graphic account of the presence of this slimy matter, and he also says it *may* be seen in movement, but not that he has himself seen it. He also speaks of "the viscid streams" of *Bathybius*, but has not stated that he has himself witnessed the phenomenon of 'streaming' in the albuminous slime in question. Finally, he states that he is by no means satisfied that *Bathybius* is the permanent form of any distinct living being. Different samples differ in appearance and consistence, and Professor Thomson thinks it not impossible that a great deal of 'bathybius' is a formless condition, connected either with the growth and multiplication or with the decay of many different things. From the Challenger we hear that one of the naturalists has paid great attention to the ooze, with the object of 'making out' *Bathybius*. He finds that the Globigerina mud is full of the pseudopodia of that Foraminifer, worked up more or less into a general slime. When alcohol is added to this the pseudopodial matter is precipitated, and this is the precipitate figured by Haeckel as *Bathybius*. If large living specimens of the Foraminifera are separated by the sieve from the mud, and then placed in alcohol, a similar precipitate is obtained. So far, the prospect is not very hopeful for the ultimate success of *Bathybius*. But it would be a mistake to give up the hypothesis as yet. Professor Edouard van

Beneden, who recently spent some time on the coast of Brazil, had the intention of making a special investigation of the Bathybian question, and his results have not yet been announced.

Development of the Mollusca.—The embryology of the Mollusca is beginning to find students in Germany. In the 'Niederlandisches Archiv für Zoologie,' vol. i, part 1, is a paper by Dr. Emil Selenka, the editor, on the "First Formation of the Embryo in *Tergipes claviger*," illustrated by a plate. In part 2 the same author has a paper on "The Primitive Layers of the Embryo in *Purpura lapillus*," also well illustrated. Both these papers belong to the newer embryology; that is to say, the author occupies himself with the exact following out of the origin and disposition of the cellular elements of the embryo. In his paper on *Purpura* Dr. Selenka proposes to distinguish two modes of formation of the blastoderm—"epiboly" and "emboly." The former is accompanied by the presence of a large food-yelk, and the egg is consequently meroblastic, or partially so. The first formative cells grow *over* the partially segmented or wholly unsegmented coloured yelk. In emboly the egg is holoblastic, and a pushing in of the cells of the primitive blastosphere takes place.

Dr. Salensky, of Kasan, has a paper with several plates, on "The Development of the Prosobranchiata," in 'Kolliker und Siebold's Zeitschrift,' 4th part for 1872, which has much interesting matter on the "Veliger" larval-form of various genera, but does not deal with histogenesis.

The Development of Gastropoda opisthobranchiata is the title of a paper by Dr. Paul Langerhans in the same journal, part 2 for 1873, in which some points in the early development of *Acera bullata*, *Doris sp.*, and *Æolis peregrina* are shortly treated from the point of view of the germ-layer theory.

Development of Rotifera.—The paper by Dr. Salensky, of Kasan, on "The Development of the Rotifer *Brachionus urceolaris*," of which we gave last year a brief notice, is published in full, with a coloured plate, in 'Koll. und Sieb. Zeitschrift,' 1872, 4th part.

Development of the Bryozoa.—Dr. Heinrich Nitsche, in the same journal, has an interesting note *àpropos* of Metschnikoff's observations on the development of *Alcyonella*. Nitsche has made a detailed study of this at Leipzig, and we may anticipate a memoir from him on the subject. Meanwhile Professor Smitt points out that in relation to certain reproductive processes he has been misunderstood by Nitsche,

owing, as he supposes, to the difficulties of the Swedish language. We may hope that Professor Smitt will add himself to the number of those Scandinavian naturalists—including Mr. G. O. Sars and Professor Thorell—who have recently adopted the English language for the purposes of scientific publication.

The Formation of the Ovum, Fate of the Germinal Vesicle, and First Appearance of the Blastoderm in the Bony Fishes and other Vertebrata.—We are not able to do more on the present occasion than draw the reader's attention to the important work and controversy which is going on upon these questions.

The papers of Dr. Oellacher are to be found in 'Schultze's Archiv,' vol. viii, part 1, and a more recent paper in 'Koll. und Siebold's Zeitschrift,' vol. xxiii, 1873.

Van Bambecke has published in 'Comptes Rendus,' t. lxxiv. No. 16, April, 1872, a paper entitled "Premiers effets de la fécondation sur les œufs des poissons," &c.

Professor His has published a separate work at Leipzig, lavishly illustrated, on the structure and mode of growth of the egg of bony fish.

Dr. Goette treats of the same general questions in a paper in 'Schultze's Archiv,' vol. ix, 4th part, 1873. References to the earlier papers of Stricker, Klein, &c., are given in the above papers.

PROCEEDINGS OF SOCIETIES.

Royal Microscopical Society.

June 4th, 1873.

Charles Brooke, Esq., F.R.S., President, in the chair.

A paper was read by Mr. Kitton, of Norwich, on "*Aulacodiscus formosus*, *Omphalopelta versicolor*, &c." giving an account of certain species of Diatomaceæ, some of them new, from the harbours of Peru and Bolivia.

Mr. J. W. Stephenson took the opportunity of stating that to his surprise, he found that the mode of dividing the cone of light in his erecting binocular microscope by means of two prisms was used by Professor Riddell, of New Orleans, in the year 1853, in his form of binocular. The arrangement of that instrument differed, however, from his own in certain respects. He had only just heard of Professor Riddell's invention.

Mr. Stephenson then read a paper entitled "Observations on the Inner and Outer Layers of *Coscinodiscus* when Examined in Bisulphide of Carbon and in Air." The paper introduced a method of "Determining the structure of minute organisms by means of the refractive indices of the media in which they are examined." Attention had lately been drawn to this method by Mr. Charles Stewart, who had applied it to determine the composition of specules in Echinodermata. Its result in the preseut instance was to show that the central spot in certain hexagonal areolæ of *Coscinodiscus* was really a perforation and not a depression or elevation.

October 1st, 1873.

C. Brooke, Esq., F.R.S., President, in the chair.

A paper was read by Dr. Maddox "On an Organism found in Fresh-pond water." These bodies, found in a small pond in the New Forest, appear to belong to the Protozoa. They consist of irregularly circular or sub-globular sarcodic or muco-gelatinous masses, often very bright at the edge, containing small granular or corpuscular bodies of various sizes and of a highly refracting nature, the whole having a very strong *violet* or *lilac* tint when seen by transmitted light. The masses differ very considerably in dimensions, the smallest containing only a few of the capsules, the largest a very great number. In many of the medium size and most, if not all, of the larger ones, the general

mass appeared to be vacuolated, often very irregularly, with the outlines of the vacuoles indistinct, or rather ill defined. Upon long watching, the relation of these to each other might now and then be seen to alter, yet there was no appearance of pulsation. In only those examples were any projections noticed having the character of pseudopodial protrusions, and these were exceedingly delicate, short, and seemed ill-fitted for progression of the masses in the ordinary manner of pseudopods. There was a slight change of general shape, but no complete revolution. No motion was seen in the imbedded masses. Some of the masses appeared to have a certain tendency to diffluence; in others, the substance was condensed into a distinct structureless cell membrane or cell envelope. When this was ruptured, the small granules or corpuscles were set free and moved about much after the fashion of mobile zoospores. The author finds it difficult to relegate these bodies to any definite place amongst either the Phytozoa or Protozoa, though they fall he thinks more nearly to the naked Rhizopoda.

A paper by Mr. Kitton of Norwich, on some new species of Diatomaceæ, was taken as read. The species described were from the genera *Aulacodiscus*, *Stictodiscus*, *Isthmia*, *Nitzschia*, *Tryblionella*.

Mr. Wenham made some remarks upon the microscopical effects produced upon glass, by which the "sand-blast process," which was exhibited at the recent meeting of the British Association.

Mr. Stewart exhibited under the microscope a specimen of a spermatophore of the common squid (*Loligo vulgaris*).

November 5th, 1873.

Charles Brooke, Esq., F.R.S., President, in the chair.

A paper was read by the Rev. W. H. Dallinger and Dr. J. Drysdale on some further researches into the Life History of the Monads.

The authors have succeeded in making out the life history of three forms which they believe to be hitherto undescribed,

The form which they specially notice is met with in vast numbers in the putrefying fluid resulting from the maceration of any of the Gadidæ. Its average length is about $\frac{1}{3000}$th of an inch, its form oval and it is furnished with flagella. It exhibits a remarkable mode of fission, by close observation of which (with a $\frac{1}{50}$th of an inch object glass), the authors arrived at the life history thus summarised. The usual method of multiplication is by fission, which goes on apparently to exhaustion. Amongst enormous numbers there are a few distinguished from the others by a slight increase in size, and the power to swim freely. These become still;—for a time amœboid—then round; a small cone of sarcode shoots out dividing and increasing with another part of flagella. The disk splits, each side becomes possessed of a nuclear

body, and two well-formed monads are set free. These swim freely until they attach themselves to an ordinary form that has just completed fission, so that the nuclei are approximate. Sarcode and nuclei melt into each other; the form becomes free, swimming and irregular in shape—rests—loses its flagella; becomes clear and distended; then bursts at the angles, pouring out indescribably minute granules from which myriads of new forms arise and repeat the cycle.

Mr. Alfred Sanders read a paper "On the Art of Photographing Microscopic Objects," in which he showed that the costly apparatus and elaborate arrangements frequently regarded as essential to success might readily be dispensed with, and the most satisfactory results obtained with appliances of the simplest kind.

Mr. S. J. M'Intire read a paper entitled "Notes on *Acarellus*," in which he described certain insects found parasitic upon *Obisium*, and closely resembling the *Hyopus* of the Micrographic Dictionary, and the insect mounted by Mr. Topping under the name of "Parasite of House-fly." The paper was illustrated by drawings and specimens, both alone and mounted.

Medical Microscopical Society.

The following is an abstract of Mr. Hogg's paper read at a previous meeting of the Society on "the Pathological Relations of the Diphtheritic Membrane and the Croupous Cast."

Much misapprehension rests on this subject; some practitioners decide at once on what they believe to be the character of the membrane. Other authorities, as, for instance Sir T. Watson, give in their adhesion to the unity of all membranous affections. Although the epidemic of diphtheria in 1858 and 1859 attracted much attention to the subject, and many specimens were exhibited by members of the Pathological Society of London, very conflicting statements were made about their histological character. In the author's opinion, the diseases are very different. "While one disease, diphtheria, is most decidedly epidemic and endemic, often wide-spreading and affecting a large proportion of adults, and probably belonging to a specific form of fever; the other, *croup*, is essentially sporadic, often a local affection, not communicable, or only so in a small degree, as when a family predisposition exists, mostly occurring in childhood, and rarely after it is fairly passed." Histologically, also, he maintains that a sharp line can be drawn between the diphtheritic membrane and the croupous cast.

As to the naked-eye appearances, the diphtheritic membrane is a dense compact, opaque, yellowish-white or reddish-grey coloured

mass, of from half a line to five or six lines in thickness. It is usually firmly adherent to the subjacent membrane, upon which it is moulded; is more or less friable, so that when traction is made upon it with a pair of forceps, it comes away piecemeal, or in a layer somewhat resembling felt or chamois leather. If forcibly detached, a breach of surface is made, and bleeding generally follows its separation, as the mucous membrane is much congested.

The croupous cast, on the other hand, is semitransparent, delicate, and tender to handle, often gelatinous or white-of-egg-like, and of a pale yellow colour; easily separable from the subjacent surface, as an imperfect cast of the part on which it is formed, and never so closely connected with it, as to cause bleeding when removed. It is, in short, a simple epithelial layer closely resembling the skin shed by some of the lower animals—an outgrowth of epithelial cells undergoing degeneration of protoplasm and entangling granular molecules.

As to the histological characters, in diphtheria the normal tissues are seen to be replaced by an aggregation of compressed cells, molecules of fat, connective or fibrous tissue, a few crystals muco-purulent or granular corpuscles, foreign bodies as starch granules, or other portions of food, and spores of *Oidium albicans*. It is surmised, therefore, that the felt-like membrane is made up of superficial and deep tissues; mucous membranes, voluntary and involuntary muscles, and glands, and produces great tension and decomposition, or ulcerative destruction. Not a trace of columnar epithelium was seen in any specimen.

The croupous cast is seen under the microscope to consist of pavement and cylindrical or columnar epithelium, and is a transparent albuminous substance entangling the scattered contents of epithelial cells, molecular matters, fat and mucous corpuscles, and a few foreign bodies, as starch, granules involved in a homogeneous matrix. The columnar epithelium retains its cilia, each cell being filled with clear protoplasmic and nucleated contents. Fungus spores are rarely found in these films, which appear to partake of the nature of an extensive cell proliferation rather than of a transudation or true exudation.

The objects were partly examined in the fresh state, partly stained and dried; fine sections being then made and mounted in dammar or Canada balsam.

Dublin Microscopical Club.

26*th June*, 1873.

Synedra investiens, W. Sm. exhibited.—Rev. E. O'Meara showed a slide of *Synedra investiens* (W. Sm). He had found this form in Kingstown Harbour, where he believed it had been found by Captain Crozier; recently, too, Mr. O'Meara had found it on seaweeds collected by him at Howth.

Microscopic Finger.—Dr. J. Barker showed a "microscopic finger" he had himself constructed after the American model, with certain improvements, and spoke of some modifications he had been thinking of to effect certain further improvements, so as to cause the prehension of the object to be effected by a purely vertical, not sweeping, action; he hoped to experiment ere long in carrying out these alterations.

Conjugated state of Desmidium Swartzii.—Mr. Crowe recorded the occurrence of the conjugated state of *Desmidium Swartzii*, a very common desmid, but very rarely found showing zygospores. In fact, it does not seem to have presented itself to any members of the Club in that condition since the occasion on which it was recorded by Mr. Archer, 18th May, 1867. The figure given by Ralfs is very graphic, though, as pointed out on that occasion, *two* filaments are really conjugated and the spores formed from the combined contents of two distinct apposed joints, not, as Ralfs supposed, owing to the extremely close juxtaposition of the pair of flat-sided filaments, by the mere consolidation of the contents of a single joint.

Green Epistylis.—Mr. Porte showed fine examples of the green *Epistylis* commonly found growing on the shells of aquatic snails.

Reade's Prism.—Mr. Robinson exhibited some beautifully mounted diatoms by the aid of 'Reade's prism,' which, however, was not pronounced so satisfactory as that of Amici, which he had shown to the Club on a recent occasion.

Hairs from flower of Cypripedium caudatum.—Dr. Moore showed the hairs from the flower of the curious *Cypripedium caudatum*. The hairs seemed of two sorts—colourless, rather stout threads, with clavate ends, and more attenuated threads, with light red contents, these together forming the pretty *pile* apparent to the unaided eye.

29*th July*, 1873.

Fungus on Sanguisorba-leaf.—Mr. Crowe showed *Xenodochus carbonarius*, a fungus found on Sanguisorba-leaf forwarded by Rev. J. H. Vize; the elegant moniliform arrangement of the cells caused it to form an interesting object.

New Stand for Amici's Prism.—Mr. Porte showed a new arrangement by means of two "ball-and-socket" joints and

"telescopic" stem for mounting Amici's prism, which he had devised and constructed, and which he found in use a very convenient form of stand; he thought this could be produced by makers more cheaply than the ordinary stand. He was strongly in favour of this illumination, as both readily managed as well as highly effective in showing the test markings of critical diatoms, and hence as valuable in ordinary use.

Diatomella Balfouriana exhibited.—Mr. Porte showed *Diatomella Balfouriana* taken at Killarney on a late excursion thither; this diatom was in Mr. O'Meara's experience rather a rare one.

Corrigendum in reference to locality for Tryblionella debilis, Arn. —Rev. E. O'Meara desired to correct an error which had crept into the "Minutes" in reference to the record of *Tryblionella debilis*, Arnott (see the Club Minutes of 2nd Nov., 1872), which was quoted as found by Dr. Arnott in "S. Brittany," in place of "North Britain," having been found at Mary-Hill Bridge, Glasgow. For this correction the Club is indebted to its corresponding member, Mr. Kitton.

Navicula spectatissima (?) *from Seychelles.*—Rev. E. O'Meara exhibited a *Navicula* which he considered identical with *N. spectatissima*, Grev. The striation is precisely the same as that of Greville's form, but the marginal portion not by any means so wide, and the edges not waved. Only two specimens were found in the gatherings from the Seychelles.

Dasydytes antenniger, Gosse, and Chætonotus gracilis, Gosse, exhibited for the first time as Irish.—Mr. Archer showed, side by side, examples of the seemingly rare forms of "hairy-backed" animalcules *Dasydytes antenniger*, Gosse, and *Chætonotus gracilis*, Gosse. The former he had never happened to notice before, and the latter only rarely. Both occurred in gatherings from Co. Westmeath; they were both rare to Gosse himself, he having seen but one specimen of *C. gracilis*, and *D. antenniger* occurred but once to him in a pond near Leamington. They are both very elegant creatures. *C. gracilis* is large and long, elegantly marked, comparatively slow and very graceful in its movements as it glides about hither and thither; the much more minute *D. antenniger* is a headlong and restless swimmer, very difficult to catch a steady view of. Luckily on the present occasion one was caught in a little vacant enclosure amongst the dirt on the slide, and a good view was obtained. The creature seemed to have the power to depress and elevate the "antennæ."

Anthoceros lævis exhibited for the first time as Irish.—Professor Lindberg, of Helsingfors, with whose company the Club was honoured on this occasion, showed specimens of *Anthoceros lævis* taken by himself and Dr. Moore (on a recent journey to Cos. Kerry and Cork,) at Ventry, this being the first occasion of this species being found in Ireland. Dr. Lindberg showed the minutely verrucose spores, with their elaters, under the micro-

scope, and explained the peculiarities of structure of this genus.

Minute egg-shaped deposits on shell of hen's egg.—Mr. Robinson showed a portion of the shell of a hen's egg having a group of little *egg-shaped* deposits on its surface, crowded densely, which when viewed under a moderate power looked wonderfully like a group of full-sized real eggs. Such little deposits are occasionally seen on egg-shells.

28*th August*, 1873.

Diatoms from Hot Springs of Azores.—Rev. E. O'Meara brought before the meeting the general results of his examination of some collections, from Hot Springs and some way-side streams in Azores collected by Mr. Mosely, of the Challenger expedition. The majority of the sediments, in the form of solid lumps, from the former, contained no diatomaceous forms; however, one of these, described as found floating on the surface of the Lake of Furnas, and producing a tough mass like india rubber, but tenacious, contained diatoms in abundance. The gatherings put up in bottles with spirit, whether from the hot or cold water, produced diatoms, but of the common British kinds. The collections which were of the most interest were those from the very hot water, inasmuch as from such a habitat it was to be expected some light would be thrown on the question as to what high temperature can the lower organisms, animal and vegetable, endure without detriment. The following diatoms, amongst algæ and some desmids, occurred in these hot-water gatherings:—*Synedra lunaris*, *Pinnularia gibba*, *Himantidium arcus*, *Cymbella affinis*, *Gomphonema tenellum*, *G. dichotomum*.

Algæ and Rhizopoda from Hot Springs of Azores.—Mr. Archer showed several forms of Algæ met with by him in the same gatherings from Azores collected by Mr. Mosely. Amongst these were not only, as would be to be expected, phycochromaceous forms, but also chlorophyllaceous, both filamentous and unicellular. None of the former could be specifically identified, as not any examples were seen in a fertile condition. Amongst these were species of Conjugatæ—*Spirogyra*, *Mesocarpus* (most probably); various Desmidieæ; of Œdogonieæ—*Œdogonium*, *Bulbochæte;* of Coleochæteæ—*Coleochæte;* of Scytonemeæ—*Tolypothrix;* of unicellular forms—*Botryococcus Braunii*, and others; various Pediastreæ; also *Ankistrodesmus falcatus.* Not only were there these algæ, but the remains of various Rhizopoda occurred—*Arcella aculeata* (so called), *Trinema acinus*, *Euglypha alveolata*, one or two Difflugiæ; *Dinobryon sertularia* also occurred. Thus in this *hot* water occurred so many forms equally met with in our home cool pools. How high the temperature exactly of Furnas Lake, whence these emanated, was not certain. Mr. Mosely, having at the time no means of taking the temperature, seems to quote from other sources the temperature of this lake as ranging from 22°

to even as much as 90° C. The form-species in the gatherings, or those whose identity is recognisable without fructification, were absolutely the same in every respect to their congeners at home; so, no doubt, would the others prove to be, had they been in fruit. Mr. Archer hoped to revert on another occasion to the forms which had presented themselves in this interesting gathering.

Crystals from a Cactus.—Dr. Moore showed crystals from the cells of an unknown species of Cactus, of handsome appearance, probably of oxalate of lime; they produced rotund groups, the crystals radiating from a common centre, their facetted extremities forming the superficies of the globe. Mr. Tichborne undertook to examine these in a chemical point of view.

Amœboid movements of corpuscles of frog's blood.—Mr. B. Wills Richardson made a very satisfactory demonstration of the 'amœboid' movements of the white corpuscles of the frog's blood and of the corpuscles charged with refractive granules. The movements were truly amœboid and highly characteristic; the refractive granules likewise were seen in active motion in each amœboid mass containing them. Several of these were seen to move across the field, and in doing so passed, on more than one occasion, either over or under stationary red blood-corpuscles. Two of the granule-containing amœboid corpuscles, when moving in opposite directions across the field, came in contact with one another. Their apposed surfaces then became parallel, and the corpuscles themselves were carefully watched by some of the members present to see if they would "conjugate" or coalesce. Instead of doing so, however, they immediately separated, and each retraced its course to the portion of the field whence it came.. The stage used for the occasion was an ordinary Stricker's hot-stage, made and slightly modified for Mr. Richardson by Spencer, of Grafton Street, Dublin. The blood, when taken from the frog, was at once placed on the glass and with a very thin cover. To prevent evaporation a little spermaceti oil was applied with a fine sable pencil to the margin; this was done sparingly and very carefully, in order that the oil might not run in. The objective used was $\frac{1}{8}''$ Ross, but probably a $\frac{1}{10}''$ or $\frac{1}{12}''$ would be a better power for demonstrating the movements of the refractive granules to those who might be inexperienced in microscopical observation.

MEMOIRS.

Contributions *to the* Anatomy *of the* Sympathetic Ganglia *of the* Bladder *in their* Relation *to the* Vascular System. By Francis Darwin. (With Plates V and VI.)

The work which forms the basis of this paper was undertaken at the laboratory of the Brown Institution, at the suggestion and under the supervision of Dr. Klein; and it is a pleasure to me to express my great obligation to him for the kind manner in which he has in every way aided me.

In Cohnheim's latest work on Inflammation ('New Researches on Inflammation,' by Dr. Julius Cohnheim, Berlin, 1873) he describes the dilatation which may be produced in the vessels of the frog's tongue by the direct irritation of that organ. And in his discussion as to the manner in which the phenomena are produced, he states his opinion that there is no reflex mechanism effected by peripheral ganglion cells, "for, in the first place, such ganglia are not demonstrated as yet, and, in the second place, no case is known in which reflex action takes place independently of the central nervous system." It is with the first of these reasons only that we are at present concerned. It is undoubtedly true that no such ganglia have been as yet pointed out in the frog's tongue, but in other organs they have been demonstrated. Dr. Lionel Beale, in the 'Philosophical Transactions' for 1863, has described and figured cells of this nature; fig. 46, plate xl, represents "a portion of the coat of a branch of the iliac artery of the frog; upon the surface external to the muscular fibres are seen some ganglion cells in process of development with their fibres, which ramify upon the muscular coat." Dr. Beale also says, in the 'Monthly Microscopical Journal' for August, 1872, p. 57, "In the bladder of the frog I have been able to follow fine nerve-fibres from the ganglia both to arteries and capillary vessels." In another place Dr. Beale says that similar fibres may be traced in small mammals,

from the ganglia situated between the mucous and muscular coats of the intestine to capillary vessels. Dr. Klein suggested that the relations of ganglia to blood-vessels might be conveniently studied in the rabbit's bladder, where he has already pointed out the existence of numerous sympathetic ganglia ('Handbook for the Physiological Laboratory,' p. 73). The ganglia are found in considerable numbers in the bladder of this animal, but are more especially numerous in that of the dog. In the rabbit's bladder they are found most abundantly on the thickened lateral edges of the organ, along which the main blood-vessels also take their course; in the dog they are more numerous on the posterior than on the anterior surface of the bladder.

The method employed was that recommended by Dr. Klein (loc. cit.), viz. "bits of the fresh bladder are coloured with chloride of gold, and then steeped in acidulated water until they swell out into a gelatinous translucent mass, then membranous fragments stripped off with the forceps, or snipped off with the scissors, are spread out and covered in glycerin." I found it best to keep the bladder intact until after it had been treated with the acidulated water; if it is cut in half, the two pieces turn inside out as they swell up, and it is then very much more difficult to snip off thin strips from the external surface. The fragments should be placed on the glass slide with their external surface downwards.

The ganglia are situated in the external coat of the bladder, and are of such a size that many of them, in the dog's bladder at least, can be seen with the naked eye. Fig. 1 represents the posterior surface of the bladder of a young puppy, as seen with a very low power. It shows the general arrangement of the ganglia and the manner in which they are connected with each other by nerve-trunks; it will be noticed that they form chain-like plexuses running with the principal blood-vessels of the bladder; a chain of minute ganglia may also be remarked running partly round the base of the bladder.

The ganglia are of various sizes: the largest one observed has a long diameter of 0·9 mm., and a transverse one of 0·72; one of the small ganglia is 0·09 mm. in length by 0·045 mm. in breadth. They present considerable variety in their shapes and have irregular outlines, which may be roughly circular, oval, or polygonal. The nerve-trunks with which they are connected are made up of non-medullated nerve-fibres, with a *few* medullated fibres appearing occasionally. The ganglia are either situated at the points of intersection of several nerve-trunks or they are found seated on single trunks. In the former case the groundwork of the

ganglion is made up of fibres passing in different directions, which form the means of communication between the different nerve-trunks; around this fibrillar core the ganglion cells are arranged, and with it their processes are incorporated. Contiguous nerve-trunks often communicate with each other by fibres which do not pass through the ganglion, but which form a peripheral meshwork, as at the smaller end of ganglion I in fig. 3. When the ganglia are not thus situated at points of intersection and interchange, they are found to be connected, as before stated, with single nerve-trunks. The simplest form of ganglion is that figured by Dr. Klein in the Handbook, where the nerve-trunk is enlarged at one place by a group of ganglion cells lying among its fibres. In other cases the number of cells is greater, and the ganglion presents the appearance of a cluster of cells traversed by a nerve-trunk; there is a variety of this arrangement in which part of a nerve-trunk forms the axis of a ganglion, while the remainder of the fibres pass close underneath the ganglion without being connected with it. Lastly, a ganglion may be situated on a nerve-trunk at its point of departure from a larger one, and in that case usually receives recurrent fibres coming from the parent trunk beyond the point of division.

The ganglion *cells* are of irregular spherical and ovoid shapes, and are about 0·02 mm. in length; they are made up a finely granular substance, and contain a single vesicular nucleus (or two nuclei), which is usually eccentric, and always contains a large shining nucleolus. All the cells whose processes can be distinguished are unipolar; fig. 6 shows a number of such pear-shaped cells forming a small ganglion; also the nucleated capsule in which each cell is contained.

In many of my preparations these ganglia possess a special system of blood-vessels, small arteries, and capillaries. In one of them there is a small artery running along one border of a very large ganglion; it gives off branches, which accompany the principal nerve-trunks arising from the ganglion, and also two branches for the blood supply of the ganglion; one of these passes up on the right, the other on the left, of the ganglion; they curve round to the upper border of the ganglion, so that it is nearly surrounded in an arterial circle. Of the branches given off from this circle, some anastomose with capillaries running with the nerve-trunks of the ganglion, and others pass into the ganglion and supply it. In many cases the ganglia are surrounded by networks of capillaries; an example of this arrangement may be seen in fig. 3. It will be noticed that the nerve-trunks belonging to

the ganglion are accompanied by capillaries (D), which run either singly, or in pairs, one on each side of the trunk. As they approach the ganglion they give off branches, which anastomose with similar branches of other capillaries, and thus form a network, from which branches pass into the ganglion. In other cases there is no such entwining plexus, and capillaries may be seen simply running up to the ganglion, and entering it in the intervals between the ganglion cells.

Having thus briefly described the ganglia and the nerve-trunks, I shall proceed at once to consider their relations to the blood-vessels. Fig. 1 shows, as already stated, that the course of the nerves corresponds in a general way with that of the principal blood-vessels. Fig. 2 is a portion of a nerve-plexus seen with Hartnack No. 4, and shows in a more minute way the character of this relation. A description of this preparation will serve, perhaps, better than remarks of a more general nature, to make the reader acquainted with the usual relations existing between arteries, veins, and nerve-trunks in the bladder of the dog.

The vessels represented are an artery (A) and a vein (A_2), with a large branch given off by each of them. A large nerve-trunk (B), on which are situated a number of ganglia (C), runs parallel with the artery, and at some distance from it; a somewhat similar trunk runs with the vein. We may call these two, for the sake of convenience in description, the "arterial" and the "venous" nerve-trunks. The venous nerve-trunk is not in reality connected more with the vein than with the artery, and might more fairly be called a second arterial nerve-trunk. Indeed, it does not occur at all in most of my preparations; what we usually find is an artery accompanied by its vein on one side, and by a ganglionated nerve-trunk running on its other side.

The figure shows in what sort of way these two large nerve-trunks, the arterial and the venous, are connected by smaller trunks. The already mentioned branches of the artery and vein are accompanied by a ganglionated nerve-trunk, coming from a large ganglion on the arterial nerve-trunk.

In addition to the two large nerve-trunks, it will be seen that the main artery is accompanied by smaller ones, which are connected with the ganglia of the plexus, especially with those on the arterial nerve-trunk; these trunks run close to the artery, and are connected with each other by transverse nerves, so as to enclose the artery in a kind of coarse mesh-work.

These smaller trunks are represented in fig. 2 as abruptly truncated in some places; in reality, it is at these points that the artery receives its nervous supply, the trunks being here seen to enter the adventitia, where they fade away, and gradually lose themselves. The veins are not accompanied by any such plexus of smaller nerves.

In some preparations, chiefly from the bladder of the rabbit, there is a somewhat simpler method of supply; here we cannot distinguish a large nerve-trunk, and an entwining plexus of small nerves, but the artery is accompanied by a ganglionated nerve-trunk, whence branches pass directly into its adventitia.

Figures 3 and 4 are drawn from a preparation of the rabbit's bladder, showing this kind of arrangement. The artery A in Fig. 3 is accompanied by a nerve-trunk, on which are situated the two ganglia I and II, which are in reality connected by the continuity of the trunks B_1 and B_1. A nerve-trunk (supposed to be interrupted at the line *ef*) comes off from ganglia I; it enters the adventitia of the artery, and disappears at *a*, where it almost meets a similar trunk coming from ganglion II. Ganglion I gives off another trunk, which supplies the artery in a different manner.

This is shown in fig. 4, B representing the nerve and A the artery. The diminution in size, which may be noticed in the nerve after it has crossed the artery, is due to the loss of several of its fibres, which enter the adventitia of the artery at *a*.

The fact that nerves are found arising from ganglia, and distinctly supplying arteries, is again illustrated in fig. 5. A ganglionated nerve-trunk, not shown in the figure, runs, roughly speaking, parallel with the artery (A); B_1 and A_1 the principal nerve-trunks of the artery, are connected with two ganglia situated close together on this trunk. Where B_1 reaches the artery it divides into two sets of fibres, one of which passes superficial to, the other in the depth beneath the vessel. The superficial division gives off a few fibres, which enter the adventitia (*a*), and then divides into two branches; one of these loses itself in the adventitia on the opposite border of the artery, the other ends by spreading out into an irregular fan of nucleated fibres on the superficial surface of the vessel. The nerve-trunk A_1 also divides into two branches, one of which terminates close to the last described branch of B_1, and in the same way, *i. e.* by spreading out on the artery, and the other comes to an end in the adventitia. The distribution of that part of B_1 which passes beneath the artery is unimportant; it is connected

with a small nerve-trunk running with the main artery, and with another one accompanying a branch which the artery gives off.

Cohnheim appears to think that it is necessary for the supply of an artery that there should be ganglion cells situated in the coats of the vessel itself. From what has been said, it will be seen that this is not necessarily the case. The arteries are accompanied by ganglionated nerve-trunks, and the ganglia are sometimes situated on the adventitia, but in that case they do not appear to be more instrumental to the nervous supply of the artery than ganglia which are not so situated.

There is very little to be said concerning the smaller arteries. I have already mentioned that the branches of large arteries are accompanied by ganglionated nerve-trunks, which are connected with the nerve-plexus belonging to the main vessels. Arteries of smaller size are often entwined with delicate, nucleated, nerve-fibres, but I have not been able to trace these fibres to ganglia.

The veins appear to be very scantily supplied with nerves; I have only been able to make out, in one preparation, any connection between them and ganglionated nerve-trunks. In this preparation there are a small number of ganglia, and a few rather small nerve-trunks; these form a very irregular plexus, which appears to be connected with two large veins, but not with the artery which accompanies them. A ganglion is seated on one of the veins, and a trunk arising from it most probably supplies the vein, as it appears to lose itself in the adventitia.

With regard to capillaries my observations are more satisfactory; I have distinctly seen delicate nerve-fibres arising from the cells of a ganglion, and supplying the neighbouring capillaries, which in some cases form part of the vascular plexus which surrounds the ganglion.

A FURTHER RÉSUMÉ OF RECENT OBSERVATIONS *on the* "GONIDIA-QUESTION." By WM. ARCHER, M.R.I.A.

IN his critical enumeration of the Lichen-flora of Denmark, Norway, Sweden, and part of Russia, Dr. T. M. Fries[1] criticises the remarkable hypothesis of Schwendener as to the nature of lichens, of the literature of which a general *résumé* has lately appeared in these pages.[2] As the observations upon this hypothesis by Dr. Müller[3] had escaped being alluded to, it appears advisable, in order to place the matter as fully as possible before the readers of this journal, to give an abstract of them as well as of the conclusions arrived at by Bornet and Treub in recent memoirs, which fully endorse Schwendener's views.

As will be now widely known, Schwendener's theory supposes Lichens to consist of two primarily distinct elements—Algæ and Ascomycetes—in such a way that the Algæ, or group of algal cells, becoming surrounded and involved, or (more rarely) permeated by the Ascomycete, serve the latter as assimilating host-plant. The two together form the "Lichen;" hence the former, long known as "gonidia," are not *organs* of the Lichen, but foreign organisms pressed into its service, and so compelled to lead a new life.

Fries asks the all-important question, "In what manner do the gonidia enclosed in the lichen-thallus originate?" Prof. Schwendener, in his lately published discussion of the subject, argues that no one has observed the development of the gonidia from terminal cells of the hypha.[4] However, Dr. Fries asserts that the hypha-branches swell up at the apex, gradually become globular and afterwards filled with green contents. Thus each becomes eventually a *gonidium*, which subsequently subdivides. As Dr. Müller observes, if this were true the Schwendenerian theory would evidently be no longer tenable. Fries does not state in what lichens he had made his observations. However, Müller refers to a previous observation of his own in *Synalissa*, bearing out the statement, and showing the gradual formation of gonidia

[1] Fries, 'Lichenographia Scandinavica,' Pars prima, Upsala, 1871.

[2] 'Quart. Journ. Micr. Sc.,' vol. xiii, n. s., p. 217.

[3] 'Flora,' 1872, p. 90.

[4] Schwendener: "Erörterungen zur Gonidienfrage," in 'Flora,' May, 1872. Translated (in part) in 'Quart. Journ. Micr. Sc.,' vol. xiii, n. s., p. 235.

from the hypha-branches; hence, for the *Omphalarieæ* or for the *Glœolichenes* (Fries), he holds the new theory to be impossible. He would be inclined to assume for the remainder of the class that—at least as regards the primordial gonidium of the gonidia-colonies—there must have existed a genetic connection between it, the gonidia, and the hypha, but that it may be probable that this formation of gonidia from the hypha-branches may take place only in the very young condition of the thallus, and that subsequently the gonidia increase merely by subdivision.

As regards *Collemeæ*, indeed, and the experiments instituted by Reess[1] in causing its spores to germinate on *Nostoc*, and develope in the substance of the latter a richly-ramified mycelium, and thus (as Reess and Schwendener hold) convert the *Nostoc* into *Collema*, Müller, whilst accepting the facts, has another interpretation to propound. This he sums up in the following terms:—

1. *Collema* is dimorphic, and it has (1) a perfect state in which it possesses hyphæ and fructifies, and (2) a secondary state (known as *Nostoc*) which never bears either hyphæ or apothecia.

2. The secondary (not, perhaps, merely younger) *Nostoc*-state of *Collema* reaches the perfect state only through the penetration into it of the hyphæ belonging to its perfect condition, which are derived from a spore or simply from "root-hairs," and through a "vegetative copulation" (so to say) of the hyphæ with the gonidia.

3. *Collema* in perfect (hypha- and apothecia-bearing) individuals propagates itself mostly by soredia.

4. An increase of perfect individuals is also possible by spore-germination, but a secondary development of simple gonidia (*Nostoc*) must precede it; the former then acquires the faculty of producing apothecia by means of the spore-filaments or root-hairs (of *Collema*) penetrating into the latter.

5. Simple spore-germination without the co-operation of the secondary state (*Nostoc*) produces no thallus (gonidia and hyphæ), and, on the other hand, simple gonidial *Nostoc*-formation, without the co-operation of the perfect state (spore filaments or root hairs), remains destitute of apothecia.

Thus, Dr. Müller would take *Collema* for the complete state, *Nostoc* for the secondary state of this dimorphic plant,

[1] Reess: "Ueber die Entstehung der Flechte *Collema glaucescens* Hfmm. etc.," in 'Monatsbericht d. k. Akad. d. Wiss. zu Berlin,' Oct., 1871, p. 523.

but he declines to assent to the idea that an alga, *Nostoc*, through the parasitism upon it of a fungal mycelium, forms the aggregate which, merely from custom, as he holds, we please to call a Lichen. The whole is, accordingly, in his view, a " special kind of partial alternation of generations," which calls to mind certain of the phases of the complicated fructifications in Algæ. Different other conditions in the Lichens are doubtless still to be expected.

Nor does Müller hesitate to regard the heteromerous Lichens in the same way, and thus many of the beautiful researches of Dr. Schwendener will, he holds, find a new and more natural interpretation. In the high Alps, amongst huge expanses of rocks, far removed from woods, where no Ascomycetes occur, where algæ are but rare, and mosses scanty, Lichens are yet met with, often in great multitudes. That view in such cases seems most reasonable which, in conformity with the foregoing conception, restores to the Lichens their autonomy, and concedes to them the power of reproducing themselves in two, perhaps in several, ways, and makes their existence not merely dependent upon a fortuitous parasitism.

A very elaborate memoir bearing on the question, with copious figures, has lately appeared from the pen of Dr. E. Bornet. As an abstract of this most interesting communication has already appeared in " Grevillea,"[2] it is unnecessary to attempt to repeat at any length, or even to try to successfully condense, the substance of so extensive a memoir.

The object of the author is to put forward a series of observations, which he regards as fully confirmatory of the parasitic theory in lichens, and as being, indeed, the only one which satisfactorily accounts for all the established facts. Passing in review a long series of lichens, first those with chlorophyllaceous, then those with phycochromaceous gonidia, he avers that there is nowhere any evidence that these ever originate from the hyphæ, but, on the other hand, that the union of the latter with the algæ is a subsequent occurrence. He brings forward certain cases in which this union is something more than any mere contact, and in which a penetration by the hypha into the interior of the cell of the alga takes place; whereupon, an increase in its size with a thickening of the wall ensues, succeeded by a

[1] Bornet, 'Recherches sur les Gonidies des Lichens,' in 'Ann. des Sciences Naturelles,' 5 sér., t. xvii, p.

[2] 'Grevillea,' No. 15, Sept. 1873, p. 36.

change in the appearance of the contents, which become colourless, the wall shrivels up, and the cell finally appears as a dead sac.

In *Synalissa*, which, as seen above, forms a strong point, in the opinion of Müller, against the parasitic theory, Bornet adduces figures tending to show that the relations of the gonidia to the hyphæ are not genetic, but due solely to mere subsequent mutual apposition, and this sometimes of quite distinct hypha-branches to cells of the alga manifestly arising from the subdivision of one and the same gonidium. He avers that he has seen in a fertile example of *S. conferta* some of the gonidia changed into "spores" (?), as if some of the *Glœocapsa* cells (here regarded as forming the gonidial element), uninfluenced by their novel position, had pursued their normal algal course of development.

Bornet sums up the result of his researches (extending over sixty genera belonging to the various tribes of lichens) in the two following propositions:—1. Every gonidium of a lichen may be referred to a species of alga. 2. The relations of the hypha with the gonidia are of such a nature as to exclude all possibility that one of these organs can be produced by the other, and the theory of parasitism is alone able to give a satisfactory explanation of them.

Sometimes, according to the author, the alteration submitted to by the algæ is not very visible. This happens mostly when they are composed of independent cells. When they are filamentous the change is often very marked; they become distorted and broken up, the cells isolated, and the gelatinous envelopes disappear. Again, in certain cases, the general appearance of the alga is little changed, but it is the individual cells of the alga which become altered. As regards *Protococcus* and *Trentepohlia* (*Chroolepus*), these are, at first glance, little changed, but the empty cells met with in the deeper parts of the thallus seem to the author to show that they are subject to a real action of the hypha, although this may not manifest itself by any very marked deformations. The cells of the gonidial-algæ preserve, though mainly in the peripheral parts, their faculty of multiplication in the ordinary manner, though, owing to the restricted limits in which they are confined, they rarely take their characteristic form. In certain cases the vegetation of the algæ appears to be singularly stimulated by the hypha (as *Glœocapsa* and *Stigonema*, when transformed into *Omphalaria*, *Synalissa*, *Ephebe*, &c.). The gonidia again, in their turn, exert an evident influence on the hypha. On contact with them, it acquires an increase of vitality, manifested by a rapid multiplication of cells, and

production of numerous branches; the vigour of the development evidently bears a relation to the mass of the alga.

When the hypha penetrates into the frond it may become equally distributed in the mass of the alga (*Ephebe, Synalissæ*), and then the general form of the alga is but little modified. But more frequently the increase of the hypha-threads takes place in a determined direction: when they are parallel the fronds become cylindrical or clavate (*Synalissa conferta*), when they are radiate or fanlike they give rise to orbicular (*Omphalaria*) or lobed fronds (*Collema*), in the form of which the alga co-operates but feebly. But in the great majority of lichens the hypha envelopes the alga; a more or less embracing network surrounds the host-plant. It is not rare to see organs of fructification appear on a thallus hardly more than beginning to be constituted.

The theory of parasitism, the author urges, explains the origin of dead gonidia found in the deeper parts of lichens; it does away with the remarkable fact of the coincidence in the same thallus of dissimilar gonidia, some containing chlorophyll, others phycochrome—a very important distinctive character between two great groups in the lower algæ; it explains, at the same time, the almost identity of the gonidia of very diverse lichens, and the marked differences between the gonidia of certain other lichens of which the thallus and fructification are identical.

To each single species or genus of lichen there does not correspond a different alga: on the contrary, a small number furnish the gonidia for a great variety of lichens. Some lichens, under certain circumstances, accessorily invade algæ of a species different to those which normally form their gonidia. But is there sometimes a complete substitution of one species for another? *Pannaria triptophylla* shows, indeed, that this substitution is possible to a certain extent, although Bornet has in vain sought in very many lichens to effect the substitution of *Protococcus* by *Trentepohlia* (*Chroolepus*).

Bornet concludes by admitting that, as regards the ordinary mode of life of algæ and lichens, there exists a certain antagonism. Moisture, abundant and prolonged, which is favorable to the algæ, is injurious to the lichens; plunging the thallus of the latter in water for some time causes the hyphæ to perish. It was in this way that Famintzin and Baranetsky set free the gonidia and obtained zoospores from them. The partial death of the hyphæ, due to indeterminate causes, is sometimes encountered in nature. On examining

Collema pulposum after recent rain, when the thallus is swollen up by moisture, certain examples are to be met with which are in a manner dimorphic—one portion has its normal form, another much resembles *Nostoc commune*. The examination of a thallus thus deformed shows that the difference of aspect is due to the decay or local death of the hyphæ.

Professor Schwendener comes forward once more in explanation and defence of his new theory in a communication made to the Natural History Society of Basel.[2] This is, however, hardly more than a recapitulation of his already published views, put together at the request of the Society, and it does not seem to contain any absolutely new matter. After dwelling upon the parallelisms between Lichens and Fungi, he proceeds to review recent researches, from which he holds that the old views as to lichen-gonidia are rendered questionable; whilst, on the one hand, the genetic connection between the gonidia and the hyphæ remains unproved, on the other, the agreement of the former with the algæ is placed in a clear light. The more important points which he proceeds to recapitulate are:—

1. He reasserts that those hyphæ which show a connection with the gonidia do not prove that the latter originate from them. The gradual development of the gonidia by a swelling up of the end cell of a hypha has been *observed* by no one. On the other hand, he has seen in certain gelatinous lichens that this union occurs by a growing-together or "conjugation" of a hypha-branch with a fully-formed gonidium. He has seen two and three stipites passing off from the same thread in union with the cells of one connected chain, which would not be possible if, like cherries or apples to their pedicels, they stood to them in a *genetic* relation.

2. He then dwells on the resemblance or identity of the gonidia with certain *Palmellaceæ*, *Chroolepus*, &c. (already discussed in previous communications).[2]

3. These algæ in the free state reproduce themselves by zoospores. So it has been proved do the *gonidia*, but the author repeats his objections to the interpretation of Famintzin and Baranetsky.

4. Some lichens possess a gonidia system with apical and stem-cells — that is, with independent terminal growth (*Ephebe*, *Spilonema*).

The author then gives an epitomized *résumé* of the "eight

[1] Schwendener, 'Die Flechten als Parasiten der Algen,' in Verhandl. der Naturf. Gesellschaft in Basel,' 1873, p. 527.

[2] See 'Quart. Journ. Mic. Sc.,' vol. xiii. n. s., pp. 217 *et seq.*

algal-types" of the "lichen-gonidia."[1] He points out that there is a large number of lichens in which the gonidia constantly belong to the same type, this indeed being the prevalent case, whilst there are other lichen forms which evince a certain amount of oscillation in their selection of gonidia between related algal-forms. These he briefly discusses, concluding by a reference to the question of "parasitic algæ." He admits that the *parasitism* which, in conformity with his theory, must be assumed for the lichens, would remain unique in the vegetable kingdom. However, certain recent observations bring to notice cases of adaptation in a certain sense analogous. He especially quotes the occurrence of *Nostoc*-chaplets in the substance of *Azolla* recorded by Strasburger, who found these algæ in the leaves of every species of *Azolla* which he had examined, no matter from what quarter of the world they originated, which fact almost led him to suppose that this plant could not have been altogether passively related to algæ. "One might almost believe" (says Strasburger) "that the *Nostoc*-chaplets are useful to the leaves of the *Azolla* in their work of assimilation, and thus, in a certain manner, play a similar part in them as in the interior of the lichen-thallus." Schwendener then alludes to Reinke's observation of a Scytonematous plant in the interior of *Gunnera* (*loc. cit.*[2]), also to those of Cohn (*loc. cit.*[3]), and proceeds to remark that in what the dependence consists—especially as regards the processes of nutrition—is at present unknown, but that it cannot be assumed from Cohn's case that the relation is a reciprocal one. The questionable "parasitic" algæ accordingly, he holds, stand in decided opposition to the gonidia-formers; in how far, indeed, they are true parasites appears to him in the meantime still doubtful. However it may be, such phenomena, he holds, abundantly show that the conditions of dependence in which organisms may stand to one another are bound up in no particular law, but rather may make themselves evident as the expression of mutual adaptation in the most diverse modes. And thus, he urges, his doctrine of the algal nature of lichen-gonidia may contribute to place in a correct light a series of the most noteworthy adaptations which occur in the vegetable kingdom.

[1] Cohn: 'Beiträge zur Biologie der Pflanzen,' Heft II, p. 87. See also 'Quart. Journ. Micr. Sc.,' vol. xiii, n. s., p. 366.

[2] "Die Algentypen der Flechtengonidien," Basel, 1869. See 'Quart. Journ. Mic. Sc.,' vol. xiii, n. s., pp. 222 *et seq.*

[3] Reinke: 'Bot. Zeitung,' 1872, p. 59.

The brief result of experiments made by Bornet in causing lichen-spores to germinate in company with algæ is incorporated below with an English version of the record of the experiments instituted for this purpose by Dr. Melchior Treub, and detailed by him in a Memoir laid before the University of Leiden in November last.[1] The author of this memoir begins by giving in the first section an interesting and complete epitome of the history of Lichenology—more especially in its bearing on the subject in question—from Tulasne to the present. It is a pity that so thorough a *résumé* of the scattered literature of the subject is written in Dutch, a language not much read in this country; however, the more important of the references touching on the "gonidia question" have already been placed before the readers of this journal. The second section of the Treub Memoir is devoted to an account of the author's original researches in 1872 and 1873 on this question, and is repeated below pretty nearly in full, for, notwithstanding that a large proportion of his experiments ended abortively, much interest attaches to them. He ultimately arrived at results in accordance with those of Bornet, and, so far as they go, apparently very much in favour of the de-Bary-Schwendener theory.

The two following paragraphs allude to Reess's experiments, already referred to in a previous number of this journal, and to Müller's views as given above:—

1. The conclusion drawn by Fries from the experiments of Reess that, if parasitism in lichens were true, the parasite should originate first and then the host, is incorrect. The colonies of *Nostoc lichenoides* with which Reess experimented must have reached even the size of a pea; it is therefore not to be wondered at that the germinating filaments of the spores, which were designedly placed *upon* the *Nostoc*-colonies, did not become long enough to be able to reach the substratum, and, by taking up food from it to enable the filaments which had penetrated into the *Nostoc* to continue growing. If, then, *Collema* spores merely fall *upon* freely growing *Nostoc*-colonies, *Collema* would not necessarily originate in consequence. This does not, however, prevent *Nostoc*-colonies which have already grown for some time upon a substratum being subsequently able to pass over into *Collema*; for this it is only necessary that the spores

[1] Treub, 'Onderzoekingen over de Natuur der Lichenen,' Leiden (22 November, 1873). Previously the author had published a brief communication, "Lichenencultur,' in 'Botanische Zeitung," No. 46, Nov. 1873, but written in September, in anticipation of his more copious Memoir, giving the complete history of the question and the full details of his experiments.

fall not just upon but close to the *Nostoc*-colonies; the germinating filaments in this case may partly penetrate into the *Nostoc* and partly into the substratum, and all the conditions for the production of *Collema* would be complete. With much more minute algæ, which are the gonidia-formers of heteromerous lichens, these may in any case originate by later importation of spores, because even if the spore falls just upon the alga, it is possible that the germinating filaments may still reach the substratum, since they mostly far exceed in length the diameter of the algæ.

2. The explanation given by Müller of the relation between *Nostoc* and *Collema*, founded on Reess's experiments,—that we have to do with a peculiar kind of alternation of generations,—is nothing else than the last desperate effort to hold by the organic individuality of the homoiomerous lichens by means of a mere fight about words. The expression 'alternation of generations' (generatiewisseling), taken in its widest sense, is applied to the phenomenon of an organic individual in reproduction producing first a form wholly different from that which brings it forth, and only the direct or indirect progeny of *this* generation becoming like the first. Thus, to regard *Nostoc* as an 'alternation' of *Collema* it should *alone* be able to furnish *Collema*; this, in reality, is not the case, so that, without completely overstraining the expression 'alternation of generations,' it cannot be applied to the relation between *Nostoc* and *Collema*. It is clear, however, that Müller merely wants to replace the *word* parasitism by the *phrase* 'a special kind of partial alternation of generation' when he says, if the increase of perfect individuals of *Collema* takes place by spores, some gonidia must be already present, which then, in combination with the intruding hyphæ, furnish the perfect apothecia-bearing individuals. No competent judge will, I think, controvert that, following Müller's own description, we have here to do with *parasitism* in the strictest sense of the word."

The following reproduces the principal portions of the second section of Treub's memoir, recording his original researches:—

Relations between Gonidia and Hypha.—Although, in the course of the present summer, the copious treatise of Bornet has appeared, in which the relation between the gonidia and hyphæ is discussed in a decisive manner, I still feel myself compelled briefly to communicate my own long-continued researches on the above point. * * * *

It is well known that it is upon Bayrhoffer and Speerschneider's authority that the origin of the gonidia from the

hyphæ has been generally accepted up till about three years ago. According to Bayrhoffer the threads of the 'fibrous stratum' swell at the top, which swellings afterwards become 'male gonidia.' That the correctness of the observation may be strongly doubted, and must rather be credited to the observer's fancy, every one will agree with me who is acquainted with Bayrhoffer's work, in which are to be found the most extraordinary ideas about lichens. Thus, for example, according to Bayrhoffer, the thallus is composed of a male and a female stratum.

As regards Speerschneider, he stated that in *Hagenia ciliaris* at the place of transition between cortical and medullary hyphæ, gonidia originate on the hyphæ, which, apart from the green colour, very much resemble at first young hypha-branches, besides which larger gonidia occur intimately united with the hyphæ, which is a further reason for assuming that the gonidia originate from these. In his work he subsequently assumes the same mode of origin of gonidia for other lichens; in *Ramalina* several gonidia are said to originate from one hypha-swelling, and in *Peltigera* to be formed *in* the hypha. The statement is also especially noteworthy that in *Hagenia* some gonidia, amongst which very young and minute ones contain *no* chlorophyll. How is this to be reconciled with his just quoted opinion, expressed a year earlier, that the existence of their colouring substance alone distinguishes the young gonidia from commencing lateral branches?

Th. M. Fries and J. Müller last year have cursorily made known some observations of the origin of the gonidia from the hyphæ, without, however, giving figures or any description of their mode of observation.[1]

"My own researches, which were chiefly carried out with *Xanthoria parietina*, and the conclusions deduced therefrom, briefly amount to this:—

The origin of the gonidia from the hyphæ will be clearly proved only when cells still uncoloured green are found on the hyphæ, and which can be recognised as gonidia by the cellulose reaction of their walls. The occurrence of minute but already distinctly green gonidia united with hypha-branches at least furnishes no proof, because (1) Schwendener, more than ten years ago, showed that the so-called stipites might be the result of the growth of the hyphæ against the gonidia; (2) gonidia are to be found (which I have succeeded in doing many times) which are furnished with more than one stipes. Just as little is it possible to recognise by the form

[1] 'Flora,' 1872, p. 90. *Vide supra.*

whether we have to do with a gonidium not yet coloured green, or with a very young hypha-branch, because, as has already been frequently mentioned by various writers, even the very young *green* gonidia attached to the hyphæ are not different in form from young hypha-branches; how much the more should this be the case with the younger still uncoloured gonidia?

After I had satisfied myself that this was the only direction in which the research *must* be carried out to furnish wholly decisive results, I tried to gain my object by making very thin sections from the lichen-thallus, which were then treated with various reagents. I obtained the sections as thin as possible by the method of Gibelli of embedding the thallus in stearic acid. From the lump thus obtained, upon cooling, a section is made as thin as possible; afterwards the thallus-sections were freed from the surrounding stearine by means of a fine needle, or, better, by means of warm alcohol. I never succeeded, however, in perceiving very young gonidia, which were *not yet coloured green, so that I did not thus make any observation in the least supporting the origin of the gonidia from the hyphæ.*

During the research it occasionally happened that I met with detached gonidia with larger or small portions of hypha attached, from which the contents were removed in consequence of the treatment, and which had thus become completely hyaline, and seeming as if the hypha pressed sometimes a little *into* the gonidium. In order to satisfy myself of the correctness of the observation, it was necessary to view such a gonidium, by means of turning, from all sides. This, indeed, was generally not possible, because the portions of hypha attached to the gonidium were too long to admit of rolling it over in all directions. That this is necessary in order to arrive at any certainty as to the fact, follows from the possibility of ocular deception, and from the fact that we might have to do with a gonidium divided into two, between whose secondary-cells the end of the stalk-cell had penetrated, and we might only see the secondary cells superposed above one another.[1] Turning upon all sides showed me in *very few cases* that hypha-ends had penetrated *into* a gonidium. In uninjured gonidia—still with contents—I never saw it; *à priori,* one might certainly say that in such a case the observation of the penetrated hypha-end is as good as impossible. Still it deserves to be mentioned here that the observation of the hypha-ends which had penetrated never gave

[1] See Nageli's 'Beitr. zur Wissensch. Botanik,' II Heft, t. i, f. 18, a. b.

grounds for the supposition that the penetration was the result of any mechanical violence during the manipulation.

Experiments in Sowing Spores.—In order to obtain a sufficient quantity of spores, Tulasne's method was employed. The lichens were placed on plates, well moistened, and then covered by the slides, upon which, after twelve to twenty-four hours, a number of spores were found. The lichens from which the spores were taken were always gathered just previously, indeed, I took, perhaps, overmuch care not to use examples which were gathered more than a day before, and this with a view to avoid giving rise to the objection that the small quantity of the spores obtained, or the unsatisfactory results of the germination of the spores, were a result of the specimens not being fresh. It is known, indeed, that the germinative power of spores subsists but for a short time, and also that herbarium-examples of lichens, upon being moistened, give off no spores. * * * * *

To produce germination the spores were placed in a moist atmosphere. For this purpose a basin or deep plate was filled about halfway with water, and in it was placed a small saucer or a piece of stone or marble. Upon these objects, which projected above the water, were placed the slides with the spores; and over the whole a bell-glass reaching to the water in the basin, so that in this way the air of the space containing the spores soon became moist. In other cases the same end was attained by laying a sheet of glass or an ordinary plate over the basin, the last for experiments on germination in the dark.

As regards the other circumstances under which the spores were placed for germination, these varied according to the end in view in observing the germination. For different purposes, two different methods were followed, and these will be separately treated:—

I. The observation of the germination of the spores had for its object to ascertain if the germinating filament produce a kind of mycelium, some cells of which pass over into young gonidia, as must happen if the lichens are to be regarded as autonomous.

The majority of the experiments were conducted in the same way as by previous observers who had the same object in view: that is to say, the spores were placed in a moist medium. I generally left the spores upon the slides whereon they were taken; the progress of germination could thus readily be examined under the microscope. Sometimes, also, I placed the spores, by means of a drop of water, upon pieces of bark from the same tree on which the lichen grew

which had furnished the spores; by making very thin sections of these pieces of bark the progress of germination was observed. The method followed by Tulasne of letting the spores germinate on stone I never adopted, because it appeared to me that the due examination of the process of germination is by this plan very difficult; one must then, indeed, either remove the germinating spores from the substratum,—and to do this without injury is very difficult, especially when the germinating filaments are very long—or one must make the microscopic observation by means of reflected light, in which case certainly no very good results are to be expected.

On two occasions I caused the germination to take place in the presence of a small quantity of the ash of the lichens; if the substratum were then moistened by vapour some of the ash-constituents would thus be dissolved, and serve for food to the germinating filaments, in case this inorganic food were necessary in order to cause the gonidia to originate.

A great number of the experiments were partly carried on in the dark, because there was thus perhaps more chance of good results; in the new formation of cells light can, indeed, not only be done without, but it ordinarily operates even injuriously, and darkness favorably.[1]

From the middle of April to the beginning of July, 1872, I made forty experiments with spores of *Xanthoria*, *Ramalina*, and *Lecanora*.

Two to eight days after the sowing the first appearances of germination make themselves evident, the more unfavorable the circumstances so much the later. Amongst the circumstances unfavorable to germination are a too copious supply of water on the substratum, and the direct proximity of other objects as well as of other spores. If many spores lie, for instance, on the top of one another this impedes germination. The very imperfect germination of spores placed under none of these unfavorable conditions shows that there must be still other conditions which are not understood.

About a month after the sowing the protoplasm becomes in great part used up in the formation and elongation of the germinating filaments. In the first year of my experiments the germination very rarely reached the last stage, wherein the spore is wholly empty and the protoplasm used up, probably often owing to the influence of the first-mentioned unfavorable circumstances, but above all to the early occurrence of a mould upon the substratum on which the spores were placed, whereby

[1] See Sachs, 'Experim. Physiologie,' pp. 30, 31.

the process of germination becomes speedily stopped. In all my cultures the mould-formation was then, amongst the obvious difficulties, not only the greatest, but, at the same time, the one against which, notwithstanding all the means applied, nothing could be done. Now, a repetition of my researches in this year at last taught me the circumstances under which the formation of mould is to be obviated, and I carried on cultures for even three months free from this vexatious foe. I saw more spores than formerly of which all the protoplasm was used up in the growth of the germinating filaments, and in which, therefore, germination proper was at an end; I *never* saw, however, young gonidia on the germinating filaments in which, by the application of reagents, I satisfied myself completely of the presence of cellulose. If the gonidia originated from the germinating filaments, they should have already made their appearance when the filaments have used up all the reserve nutriment from the spores; they do not themselves contain chlorophyll, and thus cannot assimilate and have not the opportunity of taking up organic food for further growth.

II. Starting on the supposition that Schwendener's theory of the lichens is the true one, the spores about to germinate were brought into contact with nutritive solution for the purpose of trying in this way to cause the germinating filaments to grow, after, indeed, the reserve nutriment from the spore was used up.

It is very probable that both the plan of operations and the purpose of this part of my experiments may be at first glance taken by many as merely haphazard, above all because, so far as I know, no one has ever tried to cultivate a strictly parasitic fungus by nutrient solution only, without the co-operation of the host. This has, indeed, been done for saprophytes, and with good results, by sometimes making use of prepared nutrient substances in a fluid state, at other times of decoctions or solutions of the substances whereon the saprophytes grow. Still I think I can quite justify my plan of operation. It is known that most parasitic fungi can live only on one, or, at most, very few hosts, but the conclusion constantly drawn that the hosts are the only plants which contain the nutrient substances necessary for the parasite may scarcely hold good. The phenomenon may have another explanation. Of all the plants which contain the necessary nutritive substances for any parasitic fungus, its host (or hosts) alone fulfils the conditions of containing, at the same time, none of the substances injurious to the parasite.

Were this mode of explanation of the union of a parasitic

fungus with a definite host the true one, there would have been a chance that it would have been possible to make spores from such a parasite germinate and grow in a nutritive solution, and I still think that the second mode of explaining the restricted choice of most parasitic fungi as much holds as the first.

I applied this second method in all kinds of ways in arranging the spores for germination. If I had succeeded in causing the germinating filaments to continue growing in this manner for some time, I should have at once been able to combat the organic individuality of the lichens with a wholly new weapon.

In the choice of the nutrient fluids for the culture, I supposed that it was best to select such as had been applied with good result for the germination and development of other fungi. From the small number of these fluids I chose the two following:

(A) *Culture fluid, made use of by Boussingault for development of the Mycoderms.*[1]—Milk is coagulated with acetic acid when, all the caseine being deposited, the whey is filtered; this contains albumen phosphates, potash, soda, lime, magnesia, oxide of iron, and water. This fluid, dilated in different degrees with distilled water, was used; at the same time, in many cases there was added a little ash of the lichens whose spores were to be germinated.

(B) *Pasteur's fluid, used for the development of the Mucedines.*[2]—The composition of this culture fluid is:—Distilled water in which is dissolved an ammoniacal salt, sugar-candy, and phosphate, obtained by the combustion of yeast, the last constituent introduced by means of the ash of the lichens. This fluid was also used diluted in different degrees.

In two different methods, by means of a number of experiments, lasting from 15th April to the middle of June, 1872, it was attempted to germinate the spores of *Ramalina*, *Xanthoria*, and *Lecanora* by means of the culture fluid, and, above all, to be made to go on to develop the germinating filaments.

1. The spores were brought upon a slide with a drop of the fluid, and this placed, in the known manner, in an atmosphere moistened by vapour; here, likewise, some of the

[1] Boussingault, "Observ. relat. au Dévelop. des Mycodermes," 'Comptes Rendus,' 1860, p. 672.

[2] Pasteur, "Recherches sur le mode de Nutrition des Mucedinées," 'Comptes Rendus,' 1860, p. 710.

experiments were conducted in the dark. Though the placing of the spores in pure water acted prejudicially upon germination, still the possibility may have been that in a nutritive solution the reverse was the case; in *Peziza Fuckeliania*,[1] for example, the spores refuse to germinate in fresh water but in grape-sugar solution; on the other hand, they do so once.

2. The spores were placed on shreds of flannel saturated with the nutrient fluid, so that they should be in contact with the nutrient substances (the degree of concentration remaining constant), without being wholly immersed; the experiments were again partly made in the dark.

The pieces of flannel, which were smaller than an ordinary slide, were previously boiled for half an hour in nutritive solution, then immediately brought upon a slide into the space kept moist by vapour, and after cooling, only just taken out to place the spores upon them.

To my great regret, the results were very small; the culture fluids show themselves to be peculiarly adapted for the purpose to which they were applied by Pasteur and Boussingault; after a short time, on most of the slides on which were drops of these fluids, perfect examples of *Penicillium glaucum* might be found, whilst in the course of a week the fluid imbibed by the pieces of flannel, notwithstanding the previous boiling, upon being squeezed out appeared almost milk-white, owing to the presence of a surprising quantity of *Saccharomyces;* the lichen-spores, on the other hand, in certain cases, either did not germinate at all, or produced at any rate in germination germinating filaments, which in length stood far behind those produced by the spores which had germinated, under favorable circumstances, in a moist atmosphere.

Since the object for which these experiments were undertaken did not appear in the least capable of being attained, the result of my culture of spores of the different lichens in conjunction with *Cystococcus*-examples would thus alone have to determine whether I should succeed or not in demonstrating the true nature of the heteromerous lichens. The following will show the *modus operandi* and the result of these culture experiments.

In these cultures I set before myself the final aim of making up one or more of the heteromerous lichens out of its presumptive constituents and thereby demonstrating the justness of the theory originated by de Bary and Schwendener, in the same manner as Rees had succeeded for

[1] De Bary, 'Morph. und Physiol. der Pilze,' p. 212.

the homoiomerous lichens in his culture of *Collema glaucescens.*

In any case, after the *Collema*-cultures, it remained of great importance to confirm experimentally the presumption of a double nature for the heteromerous lichens, and the more so as such a man as Cohn acquiesces in Schwendener's views for the homoiomerous lichens, and still he regards the same views as bearing upon the heteromerous lichens as untenable.[1]

Before describing the plan and results of my own cultures I may be permitted to mention what has been done in this direction by others.

Woronine obtained no positive result by bringing thecaspores of *Parmelia pulverulenta* into contact with the young gonidia in a drop of water.[2] The second who has made experiments in the culture of spores and algæ together is Bornet, who says[3]—I placed on the fragments of lime-stone freshly broken and on fragments of bark which I had boiled in water for about a quarter of an hour a layer of *Protococcus viridis* and some spores of *Parmelia parietina.* The *Protococcus* taken on a damp and shady wall was almost pure. There were with difficulty to be found mingled some *Microcoleus* filaments, a very slender *Oscillatoria* and a small number of *Cladosporium*-spores; but I did not perceive any trace of spores or filaments of lichens. The *Protococcus* diluted in water rapidly became resolved into Zoospores. Other fragments of stone and bark received exclusively *Protococcus* or spores. . . . Germination took place in some days in the manner described and figured by Tulasne. Towards the fifteenth day the hypha was already large and ramified. Wherever it came in contact with the cells of the *Protococcus,* either isolated or in groups, it adhered either directly or by a lateral branch. I may add that the hypha attached itself exclusively to the *Protococcus,* and not to other bodies mingled therewith. It is by hundreds that I have obtained these germinations, and I have been able to ascertain with certainty that I was not deceived by accidental adherences.

The spores sown apart at the same time as the others germinated alike, but became much less ramified, and did

[1] "Sitzungsberichte d. Bot. Sect. d. Schles. Gesellschaft," in 'Bot. Zeitung,' 1872, p. 16.

[2] Woronine, "Rech. sur les gonid. du Lichen *Parmelia pulverulenta,*" 'Ann. d. Sci. Nat. Bot.,' 5 sér., t. xvi, p. 324.

[3] Bornet, "Recherches sur les Gonidies des Lichen," in 'Ann. d. Sciences Naturelles,' 5 sér., t. xvii, p. 65, 1873.

not produce chlorophyll. The *Protococcus*-cells remained as they were and did not produce filaments.

In another series of experiments I placed spores of *Biatora muscorum* on a corticolous form of *Protococcus* a little larger than the preceding. The results were the same. Unfortunately, I have not been able to conduct these germinations on to the production of a thallus. *The excess of moisture and the development of a Mucedine destroyed the young plants at the end of some weeks.*

My own culture experiments were conducted in two different ways. In one I sowed the lichen spores with *Cystococcus* upon the substratum, whereon the species are mostly found, in the hope of obtaining a young lichen-thallus, as Reess succeeded in doing for *Collema glaucescens* in his "culture in the mass." In the other the spores were brought along with *Cystococcus* on slides, and tried under different circumstances, in order to make the spores germinate, for the purpose of seeing if the germinating filaments, on coming into contact with the *Cystococcus* individuals, would wholly or partially include them, and thus, as readily perceptible, demonstrate the beginning of lichen-formation.

Culture experiments in the mass ("Kultuurproeven in het groot").—These cultures had for their object the production of a young perfect lichen-thallus, and by this means to become acquainted at the same time with the processes whereby this production takes place in nature. The substrata whereon the spores and algæ were sown were constantly those whereon the lichens I was trying to cause to originate mostly occur.

I last year went to work in the following manner:

Xanthoria-spores were sown with *Cystococcus* (1) on willow-bark, (2) on pieces of tile, (3) on very fine tile-dust (obtained by hammering), and pressed as firmly as possible in little saucers. This last substratum was chosen as admitting better than the pieces of tile, after the culture, of microscopical examination of the results.

Lecanora spores were sown with *Cystococcus* (1) on willow-bark and apple-bark, (2) on pieces of stone, (3) on stone-dust, the last for the same purpose as in the *Xanthoria* cultures.

Ramalina spores finally were sown with *Cystococcus* on oak-bark.

Shortly before use the substances serving as substratum for the culture were immersed in boiling water; in by far the greater number of cases these were, before the sowing,

further saturated with a little of the solution of the ash of the different lichens.

All these "cultures in the mass" took place in a moist atmosphere. Very soon I used instead of *freely growing Cystococcus* for my cultures, that which I had previously set free from the lichen thallus (see below). The *Cystococcus* was always furnished by another lichen than that wherefrom the spores were taken; for example, spores of *Xanthoria* were sown upon a substratum with *Cystococcus* from *Ramalina*, in order that the presumption should never occur, in case of eventual success of the culture, that the thallus was caused by the continuous growing of portions of the hypha set free whilst still attached upon some *Cystococcus*-examples, as, indeed, thin sections of some homoiomerous lichens may, under favorable circumstances, grow on afresh to become a perfect thallus.

The greater part of these experiments were carried on in the way made known by Reess as necessary to cause homoiomerous lichens to originate; the spores were first sown, and about ten days after the algæ. When this mode, however, did not afford me the least result, I then, between 15th October and 1st December, 1872, made further culture for the fifteenth time, in which spores and algæ were sown simultaneously in order to see if the mode of culture requisite for the homoiomerous lichens had acted possibly injuriously for heteromerous lichens, and was the cause of the failure of the experiment.

In this summer I have not repeated the cultures "in the mass" in a moist atmosphere; however, I have tried to obtain *Xanthoria parietina* by sowing its spores with *Cystococcus humicola* in the open air upon tiles and bark of trees, lasting from 8th July to 3rd October.

All my cultures "in the mass" of the preceding year had, in no case, the least result. After a month and a half (taken as the mean of those cultures), with the naked eye there was no trace of thallus-formation perceptible, but even a microscopic examination presented nothing resembling lichen-formation. This non-success was almost always the result of formation of mould.

In my cultures in the open air during this summer I found, more than once, on the very limited spots of the bark on which I had sown spores and algæ, after about three weeks' culture, *very distinct commencing thallus-formation;* I was never able, however, with minute microscopic examination, to find the connexion between such a young thallus and a germinated *Xanthoria* spore; this appeared almost to be

impossible. Thick sections from this substratum are much too indistinct, and very thin ones do not admit of the course of the hyphæ being followed. Now, so long as this connexion is not clear, no conclusion can be drawn from the occurrence of young *Xanthoria* thalli in the place where spores and algæ were sown, since soredia indeed might give rise to the same phenomenon. However, I may here add that the commencing lichen formations almost always were without the aspect of having owed their origin to soredia.

Culture experiments on the minnte scale ("Kultuurproeven in het klein").—The spores were brought upon slides and kept in moist air. In the beginning of my experiments I occasionally placed the slides under the microscope for the purpose of examining the advance made in germination by the spores and the growth of the algæ; afterwards, however, I left the slides uninterruptedly in the moist medium, in order to follow out the results microscopically in the conclusion of the culture. The last is much preferable, since the frequent transporting of the slides whereon the cultures take place adds to the opportunities for the dire enemy of these experiments—mould—to reach the slides.

In a part of my cultures of last year along with the spores and algæ, a little solution of the ash of those lichens whence the spores proceeded was sprinkled upon the slides by means of a little brush; in this way the moisture falls on the substratum only in little drops; this was done in order to supply the inorganic nutriment which, according to Reess, the lichens derive during their development from the substratum. That this did not take place in all cases was owing:—(1) to the fact that, however carefully I went to work, large drops occasionally formed upon the substratum, which not only hindered the germination of the spores, but also favoured the formation of mould; (2) that the application for the purpose of my cultures on the minute scale ("in het klein") was not directly necessary; the germinating filaments of a parasitic fungus must still be forced *into* or *against* the host (the first in endo-, the second in epiphytes), before *all* the protoplasm is used up from the spore, because otherwise the necessary organic nutriment is absent to enable it to execute this movement of growth.

It is probable, indeed, that on the germinating filament of lichen-spores reaching the *Cystococcus*-cells the spores often contain sufficient reserve material to enable the germ-tubes to continue growing for some time. It would further be very probable that, even after the whole of the reserve nutri-

ment of the spores was used up, the germinating filaments would still be able to continue growing for some time, without addition of inorganic food, but simply at the cost of the organic food from the algæ. Should, then, the branches of the germinating filaments probably be more delicate than the hyphæ from the perfect lichen-thallus, it might be possible to observe distinctly the first result of the contact of the germinating filaments and the algæ.

After I had gone through the course of my first culture it at once suggested itself to me that the impurity of the *Cystococcus* masses must operate peculiarly unfavorably on the success of my experiment.

Indeed, upon gathering small quantities of the algæ for my cultures, it always appeared, upon looking them over, that they were contaminated by hyphæ of minute fungi, frequently by protonemata, but, above all, by other algæ. To obviate this I determined to employ the *freely*-growing *Cystococcus* no more, but only that which I had disengaged from the lichen-thallus; this, indeed, I could do without in the least diminishing the results to be obtained, since, indeed, the most violent opponents of Schwendener's theory acknowledge the perfect agreement of the gonidia of most heteromerous lichens with *Cystococcus humicola*, and in this very agreement find a reason, indeed, to remove *Cystococcus humicola* from the algæ. We find von Krempelhuber, for instance, saying, "Den Nachweis jener Aehnlichkeit gewisser Flechtengonidien mit gewissen niederen Algen, *oder meinetwegen Identität*," &c.

One great difficulty being obviated, there still appeared a much greater and more troublesome one, namely, mould-formation. In the first period of my research (February to December, 1872) I found, I might say invariably, moulds on the substratum. Of course, the growth of the algæ and germinating filaments was in consequence very much interfered with or usually wholly stopped. I tried, in the following ways, to get rid of these troublesome enemies.

1. By means of carbolic acid, of which a drop was added to the water in the vessel intended to receive the slides, or a wad moistened with it was placed in the damp space in the bell glass. In this manner I succeeded, in some cases, in preventing the formation of mould during the culture; still this was constantly coupled with non-germination of the lichen-spores, and with a total loss of colour and contraction of the contents of the algæ. The cure was worse than the disease. By employing extremely little carbolic acid the

spores commenced germinating and the algæ remained in a living condition, but the formation of mould upon the slides was not kept down.

2. By carrying on the culture in a space supplied with air, previously purified by passing through a plug of cotton wool. In this way I anticipated that I should get rid of mould; it was further probable that the continuous access of fresh air would operate favorably.

The apparatus which I employed consisted of a horizontally placed lamp-chimney, connected at one end with an aspirator; two slides covered with spores and algæ were introduced into it, and under the slides there was a stratum of water, intended to maintain the moisture of the air; the chimney was then closed at the other end with a perforated cork, wherein fitted a glass tube, twice bent, and at the end blown out into a globe, open at one end and filled with cotton wool.

I could not expect that in this way fungal spores would be absolutely excluded from my cultures, because Pasteur found that air passed through one cotton plug still leaves germs upon a second one. Since, however, the tube through which the air passed was further bent in two places, there was a good chance that fungal-spores, which were carried by the air through the wadding would not arrive at the cultures.

An experiment with this apparatus (from October 1st to November 3rd, 1872) showed me, indeed, that it was well adapted for the purpose; still it taught me afresh how little certainty one has in the success of experiments in the culture of lichen-spores; on both the slides, though the algæ had remained in a good condition, the spores had sent out no germinating filaments, and this notwithstanding that there were present *no* apparently unfavorable circumstances.

Of all my cultures made last year on the minute scale, in which the spores germinated and the *Cystococcus*-cells remained alive, by far the most did not last longer than some three weeks; just as with Bornet, mould prevented the cultures being longer extended.

I then this year began anew some experiments on the minute scale carried on in a somewhat different manner, but still with the object of struggling against the mould-formation, in order to prolong cultures for a longer period. The slides with the spores and algæ thereon were first brought into the moistened space till there was no further trace of water and spores, and algæ had become quite dry (these were always placed upon the slides in a drop of water). By this plan one of the circum-

stances most favorable to mould-formation—moisture—was much diminished; however, it was *à priori* much to be feared that on a dry substratum, and merely in a moist atmosphere, neither the spores would germinate nor the algæ continue to live. Fortunately the conjecture was contradicted by the event. After the culture had lasted for a month, microscopic examination showed that not only mould-formation was as good as altogether absent, but also that the spores had germinated very well, and that the *Cystococcus*-cells were equally alive. I was then, indeed, able to make my cultures last from 23rd January of this year to 30th April, and had the opportunity of observing very distinctly the results of germination, which will presently be described.

Amongst my cultures on slides during the summer of 1872, amounting to seventy in number, it once happened by accident that the slides, with the spores and algæ thereon, were quite dry at starting; this, however, never struck me as a favorable circumstance; the cultures equally suffered from the mould. In this summer I have again made some cultures with slides on a perfectly dry substratum, with spores of *Xanthoria parietina* and *Cystococcus humicola*, from 25th July to 4th October, if possible with still more care than those of this winter. From these cultures, owing to mould, I obtained absolutely no result. It hence follows that summer is the most unmanageable time of year for cultures such as these, so that it is explicable how so great a number of experiments as I made in the summer of 1872, in the most different methods, have led to small a result.

After *three* weeks' culture (in 1872) I saw that when germinating filaments and *Cystococcus* cells had met together, the filaments had grown more or less over the surface of the algæ and become firmly attached thereto.[1] The constant adhesion of the filament to the walls of the algæ proves that the mutual apposition is more than an accidental circumstance.[2]

After *six* weeks' culture (in 1873) I observed that as the first result of the contact branches begin to originate; the

[1] The contents of the *Cystococcus*-cells, shaded dark in the original plate, became greatly contracted under the treatment with warm caustic potash—part of Schwendener's process for rendering the hyphæ distinct: further, the cultures were afterwards put up in glycerine.

[2] By pressure on the covering-glass Treub caused the germinating filament to move vigorously to and fro; the little branch of the germinating filament now appeared to be so firmly attached to the *Cystococcus* cell that this indeed also underwent this rough action without becoming detached.

reserve nutriment appeared to have been not yet wholly used up from the spore.

After a *three-months'* culture (in 1873) I at last saw as the result of the meeting of the filament and algæ, in the neighbourhood of the place of contact, there had originated a very great number of branches of the filaments, of which the greater number had attached themselves afresh to the surface of one or more of the algæ and had produced afresh lateral branches. The nutriment from the spores was after this period of culture wholly used up, so that the spores had become hyaline. Certain cases of copiously branched hyphæ might readily give rise to the conjecture that the hypha-mass must be supported from some other source besides the reserve material from the spore; this conjecture becomes indeed fully confirmed by comparison with those spores which under the very same circumstances have germinated for an equally long time, but *without* the filaments having encountered algæ in their way.

The results of my research may be thus briefly expressed:

So soon as a germinating filament of a spore of a heteromerous lichen, or indeed one of its lateral branches, comes in contact with an alga of the species which plays the part of gonidia-former in the thallus of the lichen, it becomes attached on the surface of the alga, growing thereupon to a greater or less extent. The first result of the adhesion is more intense growth and increase of the number of hypha-branches, which partly in their turn again become attached to algæ, and also give off lateral branches, so that ultimately the alga or algal-colony which has come into contact with the germinating filaments, becomes completely encompassed by hyphæ.

Bornet's cultures, like mine of last year, were brought to a standstill by intruding fungi. I may then indeed express my opinion that the results obtained by me the previous year and those published this summer by Bornet are equivalent. Although the results of our cultures would lead us both to infer the truth of Schwendener's theory for the heteromerous lichens, they would not however be wholly decisive, because our cultures did not last long enough to cause the whole of the reserve material to have become used up from the spores. I consider, however, as regards the nature of the organic individuality of the heteromerous lichens, the results obtained in my three-months' culture at the beginning of this year as decisive on the question, because not alone the *Cystococcus*-cells were wholly involved by the branches of the germinating filaments, but further the numerous ramifications of these last

were furnished only in part by the reserve-stuff from the spores, and thus of course for the other part were produced at the cost of the organic nutriment from the algæ involved; in other words, the germinating filaments and their branches had continued to grow parasitically when once in contact with the algæ.

Though I have then not yet succeeded in producing a perfect heteromerous lichen-thallus from its component elements, I still think I am perfectly justified in affirming that the results of my cultures are alone explicable by assuming the double nature of lichens; so that from the upholders of the organic individuality of the heteromerous lichens all arguments in its affirmation are equally taken away in an experimental way as has been previously done by Schwendener in an anatomical way."

On Staining Sections *with* Magenta. By W. Hatchett Jackson, B.A., Oxon., F.L.S.

Staining with magenta has its advantages and disadvantages. Like the ammoniacal solution of carmine, magenta stains all parts of a tissue indifferently, but, unlike carmine so used, it gives (as far as my experience goes) a much greater depth and gradation of colour. When a thick section is stained with carmine the tint given is so uniform as to be but little help towards deciphering the complex structure, but with magenta the various parts generally assume such different tints that this is not the case.

On the other hand, magenta does not answer well when a tissue has got rather a dark greenish colour from long soaking in chromic acid, nor is the staining once done permanent. This want of permanency seems to me to be due to two causes—either the colour soaks out into the preservative medium, or a salt of magenta (triacid) is formed by decomposition, especially in the presence of light.

Some time, more than a year, ago it was suggested to me by a friend that it would be a good thing if some method of preserving magenta-stained specimens could be discovered. Accordingly I set to work, and after some trouble have hit on a process which, perhaps, may be found of service. The considerations which have led me to adopt it are the following:

Rosaniline, or magenta, is a triamine, and therefore with

monobasic acids forms three salts, in which one, two, or three atoms of hydrogen are replaced by the acid radicle. The triacid salts are obtained in the presence of an excess of acid, and are all colourless, or nearly so, for the most part having a dull reddish-brown tint.[1] *All* salts of rosaniline are soluble in alcohol, ether, glycerine, and chloroform, and in fluids containing more than a certain percentage of these substances. Some, *e.g.* the mon-acetate or mono-chloride, are soluble also in water or watery solutions. Hence a stained tissue plunged into water loses a certain amount of colour, and is ultimately left in a most unsatisfactory condition. Moreover, under the influence of light and in the presence of organic matter some of the mon-acid salts undergo a decomposition by which a nearly colourless compound is formed and the preparation thereby spoilt.

It appeared to me that two things were necessary:

(1) To find a stable mon-acid magenta salt.

(2) To obtain a proper preservative fluid.

The second condition can only be fulfilled by employing a watery solution, as *all* magenta salts will dissolve in glycerine, glycerine and water, Canada balsam, dammar varnish, &c.; the first, by employing a mon-acid salt, insoluble or otherwise, unchangeable in such a preservative fluid.

The salt I have found preferable is the mono-tannate; my preservative fluid is syrup prepared in a new way.

(1) At first I stained the given tissue in magenta (solution of crystallized magenta, or Judson's magenta dye), and then washed the stained tissue in a weak solution of tannic acid. This plan is troublesome in practice, and the results are uncertain, so that at last it was given up and the tissue stained from the first with the mono-tannate. The best way of making the staining solution is this:—Prepare a strong solution of tannic acid in water, dissolve a little crystallized magenta in water (or pour some of Judson's dye into a test-tube and add some water); both solutions *must* be *cold*. *Add* the tannic acid solution *to* the magenta drop by drop, shaking the test-tube from side to side after adding each drop, and taking care not to precipitate the magenta solution *completely*. Let the precipitate settle; pour off the fluid, and wash the precipitate by decantation several times with cold water. Finally, let it partially dry, and add first a drop of acetic acid, then alcohol guttatim till it dissolves. The solution is pink, and stains very quickly and deeply.

(2) Of the preservative solution I have used two kinds, and

[1] But the mon-acid salts, on the contrary, are brilliantly coloured.

prefer the second. They are both prepared with sugar. Make a strong syrup and add to it, while hot, 3 to 4 per cent. of either sodium chloride or, what is better, calcium chloride. The first, or common salt syrup, does not readily crystallize, but will do so if left exposed to the air too long (a week or so); the second, or calcium chloride syrup, crystallizes with much greater difficulty—in fact, is practically uncrystallizable. Both are very much concentrated by exposure to air, and become quite as dense as glycerine; both mix readily with water and exercise no action on tissues beyond rendering them transparent. Neither fluid seems so liable to grow fungi as ordinary syrup, and, as far as my experiments go, I believe the growth of fungi may be entirely prevented by boiling in the water one or two pieces of white pepper. I have kept the syrup through the whole summer without a single fungus making its appearance. If ordinary sugar is employed in making the syrup it is always good to filter it before use.

Besides preserving specimens stained with magenta very well, I have found these syrups of great service in all cases where glycerine is employed.

As to the staining fluid, I use one of two modifications—either the simple alcoholic solution, or the fluid obtained by adding water short of precipitation. The best way is to add the water slowly till a slight opacity appears in the alcoholic solution, then alcohol drop by drop till it becomes clear again, but for most purposes the alcoholic solution answers very well. When a specimen is kept for some time in a rather dilute staining fluid, I have found that the effect produced is much better than when it is rapidly stained in a strong one. In fact, nuclei and cells are most stained, as by Beale's carmine. As soon as the preparation is stained it is to be thoroughly washed with water, which *sets the colour at once.* It is then soaked and mounted in the syrup, which can be used of any degree of concentration suitable to the tissue. A little of the colouring matter oozes out of the interstices of the tissue very often, but not from the tissue itself.

I generally mount the specimen on a slide, and, if thick, in a cell, and seal the thin glass with dammar varnish or Brunswick black.

Specimens thus prepared and mounted have been kept for more than a year. The colour is quite unchanged, and they have become very transparent from their long soaking in syrup.

The Gastraea-Theory, *the* Phylogenetic Classification *of the* Animal Kingdom *and the* Homology *of the* Germ-Lamellæ. By Ernst Haeckel. (Translated by E. Perceval Wright, F.L.S., Sec. R.I.A., Professor of Botany, Trin. Coll., Dublin. With Pl. VII.)

I.—The Causal Significance of Phylogenesis in Ontogenesis.

The history of the development of organisms has in these latter times entered upon a new period, in that it has raised itself from the mere empirical inquiry into facts requiring to be investigated to a philosophical interrogation into their natural causes. Indeed, the thoughtful inquirer in the domain of biogenesis has been troubled for more now than half a century in attempting to dive beneath the mere knowledge of biogenetic appearances to a deeper intelligence of their meaning, or to search after "the laws of organic development," by the too intimate connection of empirical observation and philosophical reflection. But so long as the subject of the development of the organic individual was exclusively pursued, so long could not even such praiseworthy efforts aim at a causal knowledge. Indeed, this satisfying of the necessities of scientific causality is only possible since we have begun within the last decade to investigate the natural development of organic species, and by the story of the descent of organic species to explain the story of the first appearance of the organic individual.

After Caspar Friedrich Wolff, in the year 1759, by his 'Theoria generationis' had built up epigenesis on the immovable foundations of a history of common development, and after that with this strong foundation-stone for more than half a hundred years overlooked, Christian Pander had sketched out, in 1817, the first outlines of the germ-lamella theory, Carl Ernst Baer, in 1828, in his 'Entwickelungsgeschichte der Thiere,' determined the direction, and defined the path along which all subsequent embryological research must move. In this classical work the quite new science of the individual development of animals has been laid down by the happy combination of most careful observation with philosophical reflection, as well as by the blending together of the researches of the embryologist, the comparative anatomist, and the systematic zoologistic, as the starting-point of all scientific zoology, and has become the focus around which all the different laws of this science must eventually

arrange themselves. The brilliant and pregnant works of Johannes Müller and Heinrich Rathke, which immensely enlarged our knowledge, especially among the lower animals have kept themselves quite entirely to this path; and the most important work next to Baer's essential work, which has dealt with the history of development in animals, the very valuable 'Untersuchungen über die Entwickelung der Wirbelthiere,' of Robert Remak (1851), must be looked upon as an immediate continuation of Baer's researches in this path. Its principal original value consists in this, that the empirical philosophical investigations into the details of embryology are removed from the section treating of organs to that treating of histology, and that the justness of the principles which Baer had posited in reference to the individuals of the second order—the organs, were put by him to the proof on the individuals of the first order—the cell. Through the wider extension which Remak gave to the germ-lamella theory it was at the same time raised to be the starting point of histogenesis.

If, on the one hand, the manifest correctness and perfect validity of the ideas thus introduced by Wolff and Baer into the history of development, and before all the fundamental germ-lamella theory show themselves most decidedly by the immense influence which they exercised on the very important investigations of their numerous successors; so, on the other hand, not less, though in a negative way, was their importance shown by the weakness of the few opponents who attempted to leave the path which had been pointed out to them, and to strike out into a new and quite different direction. The most pretentious of these attempts proceeded from Carl Boguslaus Reichert, who endeavoured, in numerous separate papers, but more especially in his Memoir on 'das Entwickelungsleben in Wirbelthier-Reich.' (1840), and in his 'Beiträgen zur Kenntniss des Zustandes der heutigen Entwickelungsgeschichte' (1843) to reject the germ-lamella theory, and with it the essential first principles of zoogenesis depending thereon, and in their stead to set up a wild conglomerate of fantastic conceits, that do not for one second deserve the name of scientific hypotheses, still less to be called theories. Whereas the before-mentioned authorities on embryology had laboured, by clearly expressing their ideas, and by the exposition of the laws of development, to bring both light and order into the chaotic fulness of embryological facts, and to explain by falling back on simple principles the complicated phenomena met with, Reichert attempted to reverse this process, and thereby to obtain a temporary

authority, representing the simplest facts to be highly complicated, the homogeneous as heterogeneous, and those closely allied as being very far apart. His highly obscure and confused bundle of thoughts, both on embryological and histological subjects would doubtless be very quickly indeed forgotten, were it not that he knew how to envelope them in a parti-coloured covering of bombastic phraseology, garnished with an edging of philosophical technical terms, and by such a mantle to hide the emptiness that prevailed within. Although a few were thereby truly deceived and allowed an admiring acknowledgment of his confused opinions to overcome them, yet these were themselves very soon shown up in their true emptiness by Baer, Rathke, Remak, Bischoff, Carl Vogt, and others; and thereby only showed the more clearly the fundamental security of the germ-lamella theory which Reichert had in vain sought to destroy.[1]

Just one hundred years elapsed from the appearance of the 'Theoria generationis' when the history of development received an impulse which gave a new direction to the beaten path. In 1859 Charles Darwin published his epoch-making work on the Origin of species, which, by the theory it contained of Natural Selection, brought about a highly fruitful reform of the theory of descent. This latter theory had already been put forward in 1809, by Jean Lamarck, in his deeply-meditated 'Philosophie Zoologique,' with full consciousness of its importance as a true basis of thought wherewith to found a Biological Philosophy; but it was even with it as with Wolff's equally important 'Theoria generationis,'

[1] In historical reviews of the subject of the development of organic bodies, one will frequently find mentioned with the names of Wolff, Baer, Remak, &c. &c., also that of Reichert, as one of the meritorious promoters of this subject. This can only be understood to mean that Reichert contrived through his completely erroneous and unsubstantial views of the subject of development, and by his trifling, pretentious essays, to bring about a powerful reaction. Just as in histology he helped not a little to strengthen the protoplasm theory by his strange attacks upon it, so also has he in a manifold manner, though indirectly, furthered scientific embryology by his incorrect doctrine of "enveloping membranes," by his untrue "laws of formation," and by his completely erroneous views of histogenesis. But there is no reason why, for all this, his negative services should be compared with the positive ones of Baer, Rathke, Remak, and the others, who have also energetically guarded themselves against such. There are, indeed, among Reichert's extensive embryological investigations some few useful observations (even a blind hen will sometimes stumble on a grain of corn), but, in the gross and on the whole, they are to be classed as works of the lowest class, and to be grouped with those by a Dönitz, Dursy, His, and the like. A few significant ideas, which Reichert parades as his own, he has only borrowed from Rathke and others.

it was allowed to fall into oblivion for a full half century, in the presence of a so-called "exact" natural history. Lamarck had already, with perfect precision, affirmed the common origin of all organic beings from either one or a very few of the simplest primitive forms. But as Darwin grounded his theory of natural selection on the struggle for existence, and pointed out how, under this influence, organised forms underwent a constant slow transformation, so he went far beyond Lamarck, and taught us to recognise the true effective causes of the facts taught by Lamarck—the changes brought about through inheritance and adaptability. So, also, when he next proceeds to explain thereby the origin of organic species and to build up a history of the development of species, he must needs throw, at the same time, a quite new light on the history of the development of the individual and on embryology. The intimate connection in which these two branches of the history of organic development—that of the species and that of the individual—stand to each other could not escape Darwin's notice. But in his great book, that had for its principal object the founding of the theory of selection, and also in his subsequent works (particularly in his famous work on the Descent of Man), he only devotes a proportionally small space to embryology, and its great significance is but incidentally appreciated.

In my general history of the development of organisms (in the second volume of my 'General Morphology,' 1866) I have made an attempt to establish the closeness of the intimate relation of both branches of Biogenesis, and to point out its true significance. I have there represented the palæontological history of the development of species—Phylogenesis or genealogical history—as the true causes of the mechanical efficacy of the entire developmental history of the individual which Ontogenesis or germ-history in general depends upon. Without the former the latter could, in general, not exist. The difficult part of these relations lies in this, that the connection between the two is a mechanico-causal one. Ontogenesis is a brief recapitulation of phylogenesis, mechanically dependent on the functions of inheritance and adaptability.[1]

[1] In my thesis on Ontogenesis in the twentieth chapter of my 'General Morphology' (vol. 2, pp. 295—300), I have expressed this biogenetic fundamental law thus: "Ontogenesis, or the development of the organic individual, when the series of alteration of form which each individual organism passes through during the whole term of its individual existence, is immediately conditional on Phylogenesis, or the development of the organic stem (Phylon) to which it itself belongs. *Ontogenesis is the short and rapid recapitulation of Phylogenesis dependent on the physiological functions of inheritance* (*reproduction*) *and adaptability* (*nutrition*). The organic indi-

Inheritance from a common ancestor causes the typical agreement in form and structure which is met with in the early stages of each class. Adaptability to the various surrounding conditions of life causes the differences in form and structure which the forms evolved therefrom exhibit in the different species of each class.

Inheritance as a physiological function appertains to the phenomena of reproduction. Adaptability as a physiological function appertains to the group of phenomena of nutrition as is pointed out in detail in the nineteenth chapter of the 'General Morphology' (p. 148—294).

Phylogenesis is the mechanical cause of ontogenesis. In this single proposition our principal monistic conception of organic development is clearly pointed out, and on the verity of this principle the truth of the Gastraea-theory pre-eminently depends. The consequences of this will unfold themselves a little further on. For or against this proposition must every naturalist in the future decide who, not satisfied with merely wondering at the remarkable phenomena occurring in Biogenesis, will aspire beyond this to understand their full significance. By this proposition, at the same time, is the never-to-be-filled-up gulf marked out which separates the older teleogistic and dualistic from the newer mechanical and monistic morphology. If the physiological functions of inheritance and adaptability are pointed out as the only causes of organic structure, so therewith, at the same time, every species of teleology, or of dualistic and metaphysical speculation, is withdrawn from the realm of biogenesis, and the sharp antithesis between the leading principles is therewith clearly defined. Either there exists a direct and causal connection between ontogenesis and phylogenesis, or there does not. Either ontogenesis is a concise abstract of phylogenesis or it is not. Between the acceptance of these two there is no third! Either epigenesis and descent, or preformation and creation.

In reference to this decided alternative, His deserves special notice, because he has repeatedly and definitely pronounced himself against our fundamental laws of biogenesis, and

vidual repeats during the rapid and short course of its individual development the most important of those changes of form which its progenitors have passed through during the slow and long courses of their palæontological development, according to the laws of inheritance and adaptability. This true fundamental law of organic development is the indispensable basis, upon which rests the whole inner concord of the history of development. I repeat it here, because, firstly, its acceptation is required for the understanding of the following discussion; and, secondly, because it is still combated by many respected naturalists.

against there being any condition between ontogenesis and phylogenesis.[1] He seeks, instead of this, to explain the ontogenetic phenomena in the most superficial manner by bendings, foldings, &c. &c., without being able to assign any further ground whatever, any operative cause, for these "mechanical" developmental processes. The useless display of mathematical formula which His makes cannot thereby hide the want of a true causal principle, nor lend any worth to his paradoxical fancies. As I have already explained in the 'Biology of the Calcareous Sponges' (p. 472), such fancies appear only as humorous illustrations, not fit for earnest refutation; at the same time these big blunders prove how necessary, for the workers in the difficult field of ontogenesis, is the finding one's position in the province of comparative

[1] His 'Untersuchungen über die erste Anlage des Wirbelthierleibes,' Leipzig, 1868, pp. 211—223, and elsewhere. Very characteristic of his conception of biogenesis are his general remarks on the subject in his discourse, 'Ueber die Bedeutung der Entwickelungsgeschichte für die Auffassung der organischen Natur' (Leipzig, 1870, p. 35). His considers it necessary to guard the claims of the history of individual development against the overwhelming power of the Darwin intuition," and thinks "that the whole of the arguments derived from morphology, or the history of development, in favour of Darwin are not for this reason of sufficient strength, because they by no means require, as the immediate consequences of the physiological principles of development, the explanation of the widely circuitous genealogical relationship. If the genealogical relationship of organic existence actually undergoes such expansion as enables it to take in everything which the theory undertakes to sustain, so must all typical and developmental coincidences appear as quite indisputable consequences (!!). To reason *à posteriori* from the typical and developmental coincidences to a blood relationship, rather than more practically to acknowledge the demonstrated growth, might, on a first glance, but not longer, be allowed. Such a prospect discloses the different aims of development like empty realisations of a mathematically defined circle." This explanation of His refutes itself on accurate examination. But to understand the perfect baselessness of his point of view, one need only look a little closer into the "physiological principles of development" by which His tries to "illustrate mechanically" the ontogenetic events; to eliminate the theory of descent and to deny the connection between ontogenesis and phylogenesis. Here it needs but the quoting of a single example—so characteristic is it—to show the style and manner in which His thinks to prove the principles of morphology to be necessary consequences of a mechanical development (*loc cit.*, p. 34). His says: "How simple the homology of the fore and hind limbs appears when we know that their first appearance is determined by the crossing of four folds encircling the body, like the four corners of a letter (!). How clear also becomes the once difficult comparison of the anterior with the posterior extremities of the body, when we also here go back to the primitive fact that the head as well as the posterior extremities of the body finds its termination in an unflapped fold, and that all the mechanical conditions which accompany such an unflapped fold must make their appearance in front as well as behind." It would be difficult, indeed, in the whole range of the literature of morphology, to find an example of an equally crude and superficial explanation of a morphological relationship.

anatomy and the referring the ontogenetic processes to their mechanical phylogenetic causes—their true "causæ efficientes." If His had only known a little of the facts of comparative anatomy and of the ontogenesis of Invertebrata he would scarcely have published his essays.

To perceive quite clearly the complete antithesis between this pretended exact "physiological" conception of ontogenesis and our antecedent explanation of the same by phylogenesis, it is only necessary to compare these abortive inquiries of His's with the masterly outline of the history of the development of the Crustacea which Fritz Müller has given in his eminently suggestive work, 'Für Darwin' (Leipzig, 1864). Here the immediate dependence of ontogenesis on phylogenesis is proved from the multifarious range of forms of one whole class of animals, and the former is actually explained by means of the latter.

Here we find both the formative forces—inheritance and adaptability—referred to as the true "physiological" causes of ontogenesis and the laws regulating their activity recognised. Two of the most important propositions which Fritz Müller herein lays down, and which have a special bearing on our present subject, are as follows:—The historical witness (of ancestral development), preserved in the developmental history (of the individual), will gradually become obliterated. Such development always follows a direct path, from the ovum to the perfect animal, and it will frequently, in the struggle for life which the free living larval form must undergo, put on a deceptive appearance.

The past history of the species (phylogenesis) would be so much the more fully preserved in its developmental history (ontogenesis) in proportion to the duration of its younger stages, which also themselves pass through similar phases, and so much the more truly the less the life-habits of the young deviate from those of the adult forms, and the less the peculiarities of the individual younger stages present themselves as retrogression from a later to an earlier division of life, or as independent entities ('Für Darwin,' pp. 77-81). Whilst Fritz Müller founded these laws on the ontogenesis of various Crustacæa, and from the common nauplius young form of the most different kinds thereof, he concludes that a common nauplius form was the ancester of the whole class, and he explains, at the same time, a number of remarkable phenomena, which, without this application of the theory of descent, would remain perfectly unexplicable, not to say incomprehensible. The causal bearing of phylogenesis on ontogenesis may be at once perceived therefrom.

2. The Causal Significance of the Gastraea-theory.

The application of the general biogenetic principles to the different departments of special biology, and especially to the natural systems of organisms, is a scientific problem which, it is true, must be claimed, as a matter of course, by all thinking biologists, but which encounters the greatest difficulties at every attempt to carry it thoroughly into execution. These difficulties in general chiefly depend on the low condition of development of our biological knowledge, on the little participation which biology has hitherto had in the fundamental *formative developmental functions of inheritance and adaptability*, but more especially on the great deficiencies and incompleteness of the empirical so-called "records of creation" which the three schools of ontogenesis, palæontology, and comparative anatomy offer us.

In spite of these great obstacles and difficulties, the importance of which I do not lose sight of, I have ventured, in 1866, in my 'General Morphology,' to make a first attempt to arrive at the natural system of organisms with the help of the biogenetic principles of the theory of descent, and in the "Systematic introduction to the general history of development" (vol. 2, pp. xvii—clx) to establish phylogenesis as the basis of the natural system. I have renewed and improved this attempt in a more popular form in my 'Naturlichen Schöpfüngsgeschichte' (1868; 4th ed., 1873). But, nevertheless, these first attempts (as I expressly designated them from the beginning) have, with few exceptions, encountered only lively disapproval and decided disapprobation among my immediate colleagues; but no one has troubled himself to supersede my phylogenetic system by a better one. This problem lies before any one who admits the theory of descent, and aims at a causal comprehension of organic forms.[1]

[1] The best defence against the numerous attacks which my phylogenetic system of organisms has endured seems to me to be that I am always trying to improve it, and thus to arrive at an understanding of the *causal connection of the organic form*, which cannot be arrived at in any other way. The attacks of Rütimeyer, one of the most energetic of my opponents, in whose opinion my genealogical tree does not agree with Darwinism and the theory of descent, have been already disposed of in the preface to the third edition of the 'Naturlichen Schöpfüngsgeschichte.' It is enough at present to quote the naïve sentence in which Rütimeyer himself aptly characterises his comprehension of the theory of descent:—"Darwin's views appear to me to be a species of naturalist's religion, which we can only be for or against, but the odium theologicum is admitted as a proverb, and I do not, therefore, imagine that much can come of it."

I am now about to attempt, in the following pages, materially to improve that first genealogical sketch of the natural system, and with the aid of the biogenetic principles on the one hand, and the fundamental germ-lamella theory on the other, to establish a theory, to which I attribute a causal importance, for the natural system of the animal kingdom, for the comprehension of the development of its "types," and for the natural relationship of its main groups, and which I will briefly designate, in a word, as the *Gastraea-theory*. The real purport of this Gastraea-theory depends on the conception of a true homology of the primordial rudiment of the intestine [Urdarm], and of the two primary germ-lamellæ in all animals except the Protozoa, and may be briefly summed up in the following words:—"The entire animal kingdom divides into two chief divisions: the older, lower group of the Protozoa (Urthiere), and the younger, higher group of the Metazoa (Darmthiere). The main group of the Protozoa or Urthiere (animal Monera and Amœba, Gregarina, Acineta, Infusoria) always increases only by the development of the animal individuality of the first or second order (Plastide or Idorgan); the Protozoa never form germ-lamellæ, never possess a true intestinal canal, and, especially, never develop a differentiated tissue; they are probably of polyphyletic origin, and branch off from many different primevally generated Monera. The main group of Metazoa, or Darmthiere (the six races of Zoophyta, Vermes, Mollusca, Echinodermata, Arthropoda, and Vertebrata) is, on the contrary, probably of monophyletic origin, and arises from a single common root form, the Gastraea, which has sprung from a Protozoan form; it always multiplies by developing the animal individuality of the third or fourth order (Person or Cormus); the Metazoa always form two primary germ-lamellæ, always possess a true intestinal canal (a few retrograded forms only excepted), and always develop differentiated tissues; these tissues always arise from the two primary germ-lamellæ only which have been transferred as an inheritance of the Gastraea of all the Metazoa, from the simplest sponge up to the man. Next, the group of Metazoa divided again into two sub-groups, first the Zoophyta (or Cœlenterata), which, in consequence of their habits in life, form the so-called radiate type; and, secondly, the Bilateria (or Sphenota), which, in consequence of their crawling habits of life, form the so-called "bilateral type." Among the Bilateria, the lower worms (Acœlomi) agree with the Zoophyta in the want of the cœlom (body-cavity), and of a circulatory system; and then, again, from these primary

older acœlomatous worms the higher worms (Cælomati) have secondly developed themselves by the formation of a cœlom and of a circulatory system (depending thereon). Four divergent descendants of the cœlomatous worms form the four typical most highly developed races of animals: the animal stems or phylæ of the Mollusca, Echinodermata, Arthropoda, and Vertebrata.

The firm foundation for this Gastraea-theory, and for the widely extending consequences which we are about to deduce from it, is explained in my monograph of the Calcareous sponges (1872). In the preparation of this monograph I chiefly endeavoured—firstly, to give as thorough and comprehensive a representation as possible of all the biological relations of this interesting little group of animals; and, secondly, to attempt, upon the ground of their extreme plasticity of form, "an analytical solution of the problem of the origin of species," to give an analytical proof of the truth of the theory of descent. But besides these special objects, the developmental history of the calcareous sponges, the discovery of their gastrula form, as well as the question of their natural affinities, and their place in the animal system, necessarily, and of itself, led me on to the general question of the homology of their germ-lamellæ with those of the higher animals, and thus further on to that series of ideas whose nucleus, in a word, forms the Gastraea-theory. The leading ideas, which will be developed subsequently, are all contained already in the monograph of calcareous sponges, but in it there was neither room nor fitting opportunity to develop them further. In giving here this explanation of the Gastraea-theory, I must refer throughout to the monograph of calcareous sponges for the series of special observations which serve me as a sure empirical basis.[1]

The surest possible ground from external evidence was

[1] The following passages in the first volume of the 'Calcareous Sponges' are especially to be compared:—Doctrine of individuality (pp. 89—124), histology (pp. 130—180), organology of the canal-system (pp. 210—292), development (pp. 328—360), adaptability (pp. 381—391), inheritance (pp. 399—402), and philosophy of the calcareous sponges (pp. 453—484). In the last division are the reflections on the primordial form of the sponges (p. 453), the germ-lamella theory, and the genealogical tree of the animal kingdom (pp. 464, 465), the biogenetic principle (p. 471), and the causes of the production of form (p. 481), are of special importance with respect to the Gastraea-theory. In order to avoid useless repetitions, I must again refer to these passages in the first volume ('The Biology of Calcareous Sponges'). Many relative observations are specially detailed in the second volume ('The System of Calcareous Sponges'). Illustrative figures are to be found in the sixty plates which form the third volume ('The Atlas of Calcareous Sponges').

obtained for the accurate division of the animal kingdom into the two primary sections of Protozoa and Metazoa, between which the Gastraea stands as a fast boundary-stone, by my proving the existence of a primordial rudiment of an intestine in the sponges, and my pointing out the development from it of the two primary germ-lamellæ, which furnish the same common basis for the original formation of the body, in all Metazoa up to the Vertebratæ. On the other hand, the demand arose to obtain for this firm boundary line a decisive negative security by internal evidence; that it should be proved that all the Protozoa were totally without both a rudimentary intestine and the two primary germ-lamellæ. In this respect the Infusoria only, especially the Ciliata, presented considerable difficulties, as their position, till very recently, has wavered backwards and forwards between the primitive animals, the Zoophyta, and the worms. I hope that through my lately published investigations into the morphology of the Infusoria [1] I have definitely decided this difficult question, and also have thoroughly repelled the attacks which have recently been made on the view first put forward by Siebold (1845), that the Infusoria are unicellular organisms, and therefore true Protozoa.

The celebrated researches into the ontogenesis of several of the lower animals, which A. Kowalevsky has published during the last seven years (in the Memoirs of St. Petersburg Academy), and which I must consider the most important and suggestive of all recent ontogenetic works,[2] were of especially high value to me in proving the true homologies of the two primary germ-lamellæ, in all the Metazoa, without which the Gastraea-theory cannot be maintained. However Kowalevsky does not accede to the homology asserted by me to be complete, of the two primary germ-lamellæ in the different groups of animals, and considers, for instance, that the intestinal glandular layer of Insecta, and the entoderm of the Hydroida, &c., are special structures. He also differs from me considerably about the significance of the secondary germ-lamellæ. But, on the whole, I think I may assert, that the important facts which he has

[1] 'Jenaische Zeitschrift,' vol. vii, 1873, p. 516, tt. 27, 28.

[2] The ontogenetic works of Kowalevsky, especially those on Amphioxus, Ascidia, Euaxes, Holothuria, &c., have not found by far the estimate which they deserved. This misfortune is, perhaps, chiefly due to his extremely careless and unmethodical method of description. It is very difficult to understand him, not only because his train of thought is deficient in logical sequence and consecutive arrangement, but because the illustrations are partly not described at all, partly wrongly numbered, or given without sufficient reference to the text.

discovered are strong proofs of the truth of the Gastraea-theory. This may also be said of the remarkable and valuable investigations on the ontogenesis of the lower animals which Edouard van Beneden, jun., has published in several memoirs, especially in his prize essay on the composition and significance of the animal ovum[1] (1870.)

E. Ray Lankester has lately published (in May, 1873) an essay well worth reading on the primitive germ-lamellæ, and their significance in the classification of the animal kingdom.[2] which is in substantial agreement with the succession of ideas which have led me on to the Gastraea-theory. It is true that, in particulars, we in different ways diverge, and especially different are our views of the secondary germ-lamellæ, as well as of the cœlom, and of the relation of the vascular system with the primitive segment organs. But in most respects, and especially with regard to the homologies of the primary germ-lamellæ, Ray Lankester's ideas completely agree with mine. This agreement is so much the more satisfactory, as we have been working independently of each other, and have arrived at the same result by different methods.

In regard to the conclusions which I subsequently draw from the Gastraea-theory, and some of which affect the most important principles of comparative anatomy and developmental history, as well as the classification of the animal kingdom, I must lay claim to that liberty of natural philosophical speculation (or in other words, intelligent comparison of empirical results), without which, in my opinion, general biology cannot advance a step forwards. I have fully explained my ideas of the right of necessarily combining the empirical and philosophical methods in my "critical and systematic introduction to the general morphology of organisms," as well as in my systematic introduction to the monograph of calcareous sponges, and can here simply refer to these detailed justifications for my adopting this standpoint.

In any case, proof may be given by the following disquisition, that Cuvier's and Baer's theory of types which has formed the basis of zoological classification for more, up to the present day, than half a century, has been rendered untenable by the progress of ontogenesis. In its place, the

[1] Edouard van Beneden, 'Recherches sur la composition et la signification de l'œuf,' Bruxelles, 1870.

[2] E. Ray Lankester "On the Primitive Cell-layers of the Embryo as the Basis of Genealogical Classification of Animals, and on the Origin of Vascular and Lymph Systems;" 'Annals and Mag. of Natural History,' 1873, vol. xi, p. 321.

Gastraea-theory builds up a new system on the basis of phylogenesis, the fundamental principles of which, as regards classification, are the homologies of the germ-lamellæ, and the primordial rudiment of an intestine; and, secondarily, the differentialism of the tranverse axis, and of the cœlom.

But the Gastraea-theory may attain to great importance by this fundamental remodelling of the system of zoology, as it is the first attempt to lead to a casual knowledge of the most important morphological relations, and the principal typical differences in the structure of animals, as well as to discover the historical sequence in the origin of the animal organization. Inheritance and adaptability here appear in their full light as modifying agents, and as the only two formative factors of the organic relations of form. Inheritance and adaptability are the only "two mechanical causes," with the help of which the Gastraea-theory explains the origin of the leading natural groups of the animal kingdom, and the characteristic relations of their organizations.

3. The Phylogenetic Signification of the two Primary Germ-lamellæ.

The individual developmental form of the animal kingdom, by the general distribution of which the Gastraea-theory next supports itself, is the Gastrula (Pl. VII, figs. 1—8). In the 'Biology of the Calcareous Sponges' I have applied this name to that very early stage of development in which the embryonic animal-body exhibits the simplest conceivable form of entity: a uniaxial segmented hollow body without appendages, the simple cavity (primitive intestine) opens on one pole of the axis by an orifice (primitive mouth), and the body-wall consists of two cellular membranes or lamellæ; entoderm or gastral-lamella, and exoderm or dermal-lamella.[1]

The gastrula is the most important and suggestive embryonic form in the animal kingdom. The extreme significance which I attach to it is, firstly, supported by its recurrence in animals of the most different groups, from the sponges to the vertebrata in the same characteristic form and arrangement; and, secondly, because the morphological and

[1] About the right comprehension of the individuality of the entity (as of the morphon, or of the morphological individual of the third order), compare my 'Biology of the Calcareous Sponges,' p. 113; about the right notion of the gastrula, compare l. c., p. 333. Our gastrula is identical in many respects with the embryonic animal form, which was formerly called planula; but in many other respects the so-called "Planula" is a very differently constituted body.

physiological condition of the gastrula-form throws the clearest light on the monophyletic genealogical tree of the animal kingdom. If anybody wished to construct *à priori* as simple an animal form as possible which should possess that most important primitive animal organ, the intestine, and the two primary germ-lamellæ, he would arrive at the same form which the gastrula actually represents.

I have fully described the arrangement and structure of the gastrula in the Ontogenesis of the 'Calcareous Sponges' (loc. cit., pp. 333—337). It recurs in all three families of this group of animals, and always in the same form, in the Ascones (*Asculmis armata*, t. xiii, figs. 5, 6); in the Leucones (*Leuculmis echinus*, t. xxx, figs. 8, 9); in the Sycones (*Sycyssa Huxleyi*, t. xliv, figs. 14, 15). It everywhere displays the same essential structure, and only differs in quite unimportant proportions. The uniaxial unsegmented body is sometimes globular, sometimes egg-shaped or oval; more rarely sphæroidally flattened or lens-shaped. The diameter mostly measures from 0·1 to 0·2 millimètre. The primitive stomachal cavity, or the primitive intestine (*progaster*), is of the same conformation as the body, and opens at one pole of the longitudinal axis by a simple oral cavity (the primitive mouth, *prostoma*). The two cell-layers or lamellæ, which compose the wall of the stomach, become differentiated in a very characteristic manner. The inner cell-layer, the entoderm or gastral-layer, which corresponds to the inner or vegetative germ-layer of the higher animals, consists of large, dark, globular, or subsphæral-polyhedric cells, which differ in little from the furrowed cells of the morula, and average 0·01 millimètre in diameter. The outer cellular layer, the exoderm or dermal layer, which represents the outer or animal germ-layer of the higher animals, consists of smaller, paler, cylindrical, or prismatic cells, each of which carries a long cilium, or vibratile body, and is 0·02 millimètre long and only 0·004 millimètre thick. (In the schematic representations of the gastrula, on Pl. VII, figs. 1—8, which belongs to this section, the cilia of the exoderm are purposely omitted.)

In the section of the plant-like animals (Zoophyta or Cœlenterata) the same gastrula-form occurs not only in the most dissimilar sponges, but also widely distributed in the Acalephæ,[1] in the Hydroid polypus and Medusæ, in

[1] The gastrula of the plant-like animals has already been more or less plainly described and figured in many of the older and newer works on sponges, Hydromedusæ, &c. Compare Kowalevsky's remarks "On the Development of the Cœlenterata" ('Göttinger Nachrichten,' 1868, p. 154); also the works of Agassiz, Allman, &c.

the Ctenophora and corals (Pl. VII, fig. 2). In the class of the worms the same gastrula (the so-called "infusorian-like embryo") occurs sometimes in exactly the same, sometimes in a more or less modified form, in the flat-worms (Turbellaria, Pl. VII, fig. 3, and Trematoda); in the round worms (Nematoda, Sagitta); in the Bryozoa (Polyzoa) and Tunicata (Ascidia, Pl. VII, fig. 4); in the Gephyrea and Annelida (Phoronis, Euaxes, Lumbricus, Chætopoda[1]). In the class of the Echinodermata the gastrula appears to be very widely distributed in all four divisions, especially in the Asteridæ and Holothuridea[2] (Pl. VII, fig. 6). In the class Arthropoda the gastrula is, indeed, nowhere any longer completely preserved in its original simple form, but it is very easy to reduce the earliest embryonic forms of the nauplius (as the common root-form of the Crustacea), and of many of the lower tracheal breathing forms to the gastrula[3] (Pl. VII, fig. 7). In the class Mollusca, the gastrula appears to be widely distributed, especially in the groups of Mussels and Snails, and probably also in the Spirobranchia; among the snails it has been first observed in Limnaeus[4] (Pl. VII, fig. 5). Lastly, in the class Vertebrata the orginal gastrula form is only fully preserved in the Acrania (Amphioxus, Pl. VII, fig. 8). Nevertheless the continuity which exists between the ontogenesis of the Amphioxus and of the other Vertebrata leaves no doubt remaining that the ancestors of the latter have passed through the gastrula form in earlier periods of the earth's history at the commencement of their ontogenesis.[6]

The phenomenon, that the gastrula recurs in the same

[1] On the gastrula of the worms, the works of Kowalevsky are especially to be consulted—'Mémoires de l'Académie de St. Pétersburg,' tom. x, No. 15 (1867); tom. xvi, No. 12 (1871); his ontogenesis of Phoronis, of the Ascidia, and his embryological studies on worms and Arthropoda.

[2] The gastrula of the Echinodermata are made intelligible to us by the figures of Johannes Müller, of Alexander Agassiz ('Embryology of the Starfish,' Pl. I, fig. 25—28), and by Kowalevsky ('Ontogenesis of the Holothuria').

[3] That the ancestors of the Arthropoda must also have developed themselves from the gastrula, is clearly proved by the comparison of their simplest and earliest immature condition with the gastrula of the worms. Compare especially the works of Edouard van Beneden and Bessels 'On the ontogenesis of the Crustacea,' and of Weismann 'On the ontogenesis of Insects.'

[4] E. Ray Lankester has described the gastrula of the Mollusca in a recent paper ('Annals and Mag. of Natural History,' Feb., 1873, pp. 86, 87). In many mussels and snails it is developed in exactly the same manner as in the Zoophytes, worms, Echinodermata, Amphioxus, &c.

[6] The gastrula of the Vertebrata, which only now persists in Amphioxus has been made known to us by Kowalevsky in his ontogenesis of this oldest Vertebrate animal (l. c., Pl. I, figs. 16, 17).

actual construction and form as the earlier condition of individual development in representatives of all the animal groups (except only the Protozoa), is a biogenetic fact of the greatest significance, and confirms the safe conclusion according to a biogenetic fundamental law, that all the phylæ of the animal kingdom (except the Protozoa) branch off from a single common unknown root-form, which was formed essentially like the gastrula. In the 'Philosophy of the Calcareous Sponges' (l. c., pp. 345, 347, 467) I have called this primitive, long extinct root-form; which must have existed already in the earlier primordial time (during the Laurentian period) the Gastraea. The acceptation of this root-form, whose next descendants during that period probably appeared in many different genera and species of Gastraeada, is firmly established by the homology or morphological identity of the gastrula in the most different groups of animals. It is therefore a witness of special significance that the cells of both germ-lamellæ have everywhere retained their distinctive characters (by inheritance). The cells of the inner germ-lamella or entoderm are everywhere distinguished by their undifferentiated condition ; their shape is globular or irregularly polyhedric, their protoplasm is opaque, granular, diffluent, with oil-globules, and is quickly and intensely coloured by carmine ; their nucleus is generally globular ; for the most part they are not vibratile. On the other hand, the cells of the outer germ-lamella, or exoderm, are further differentiated ; their form is mostly cylindrical or conical ; their protoplasm is pale, clear compact, with no oil-globules, and is coloured more slowly and less intensely by carmine ; their nucleus is generally elongated ; the exoderm cells mostly vibratile.[1] These are apparently more strongly modified by adaptation to the surrounding outer world than the interiorly placed entoderm cells, which have more truly preserved the original character of the morula cells. The ontogenetic formation and increase also proceeds more rapidly in the exoderm than in the entoderm cells.

From the gastrula homologous in all the groups of animals (except the Protozoa) follows necessarily the true homology of the primitive rudiment of the intestine in all animals, as well as the homology of the two primary germ-lamellæ, in all those higher animals which have lost the original gastrula-condition by the law of contracted inherit-

[1] The differences between the protoplasm of the exoderm and entoderm cells are altogether analogous to the differences between the hyaline cortical layer (exoplasm) and the granular medullary layer (endoplasm) in the unicellular animal bodies of the Infusoria, Amœba, &c.

ance. I consider this homology so extremely important that I accept in this evidence the monophyletic origin of the six groups of higher animals from the common root-form of the Gastraea, and place them all together as germ-lamella animals (Metazoa or Blastozoa) as opposed to the primitive animals which have not yet arrived at the germ-lamella stage. This consideration forms the nucleus of the Gastraea-theory, the most important consequences of which will be subsequently developed.

Huxley had, in 1849, already asserted that the two permanent foundation membranes of the Acalephæ, entoderm and exoderm, were truly homologous to the germ-lamellæ of the higher animals, see his excellent dissertation "On the anatomy and the affinities of the Medusæ."[1] Subsequently, Kowalevsky has laboured in a series of very suggestive ontogenetic works, to extend this homology over the largest part of the animal kingdom, and to show that (with few exceptions) the two well-known original germ-lamellæ of the Vertebrata also make their appearance in invertebrate animals of the most different groups. His brilliant discovery of the identical ontogenesis of the Amphioxus and the Ascidia (1867), one of the most significant and suggestive discoveries of modern zoology, was especially important in this respect.[2] This homology of the two primordial germ-lamellæ, and the organs immediately originating therefrom is carried out furthest, but, at the same time, in a partially restricted manner, in Kowalevsky's latest work, the 'Embryological Studies on Worms and Arthropoda' (1871). This theory has next met with the most acute discernment and the most decided advocacy from

[1] 'Philosophical Transactions,' 1849, p. 425:—"A complete identity of structure connects the 'foundation membranes' of the Medusæ with the corresponding membranes in the rest of the series; and it is curious to remark, that throughout, the inner and outer membranes appear to bear the same physiological relation to one another as do the serous and mucous layers of the germ; the outer becoming developed into the muscular system and giving rise to the organs of offence and defence; the inner, on the other hand, appearing to be more closely subservient to the purposes of nutrition and generation."

[2] The significant importance which we attribute to Kowalevsky's discoveries, which were corroborated by Kupffer, rests, in our opinion, on two points. First, because the deep gulf between the Vertebrata and Invertebrata, hitherto considered impassable, and a chief impedient to the theory of descent, is thereby filled up. Secondly, the original ontogenetic development of the Vertebrata, as well as of the most dissimilar Invertebrata, from the gastrula, with their common descent from the Gastraea, is thereby also proved. All the attempts which have recently been made by different authors to dispute the fact of this fundamental discovery, or to weaken its signification, appear to be so feeble, that they need no refutation.

Nikolaus Kleinenberg, in his excellent monograph of Hydra, a work which occupies a prominent position among recent morphological works by the happy union therein of the most accurate objective observation, and clear philosophical reflection. Finally, I have myself proved in the biology of the calcareous sponges (l. c. 464), that the two primary germ-lamellæ persist throughout life in the sponges in their simplest form, and that the outer animal germ-lamella simultaneously fulfils the animal functions of sensation and locomotion, the formation of the skeleton and integument, while the inner vegetative germ-layer performs solely the vegetative functions of nourishment and reproduction. I have, at the same time, applied the germ-lamella theory directly to the monophyletic genealogical tree of the animal kingdom, and have thus attempted to supply a firm biogenetic basis for a Natural system.

Only the two primary germ-lamellæ and the primitive intestinal cavity which they enclose can be considered as completely homologous, in the strictest sense, throughout the whole animal kingdom (*i. e.* after excepting the Protozoa, in all Metazoa, from the Sponges to the Vertebrata). The two cell-layers of the gastrula and of the Gastraeada which it repeats, as well as the exoderm and entoderm of the sponges, are, in this strictest sense, doubtless completely homologous with the two primary germ-lamellæ in the embryos of the Vertebrata, Arthropoda, Mollusca, Echinodermata, and Vermes. The apparent difficulties in the way of this complete homology caused by the formation of a nutritive yelk (and the consequent partial grooving incident thereto) in most of the higher animals are easy to set aside and to explain by secondary adaptation. On the other hand, this homology becomes incomplete as soon as the two primary germ-lamellæ begin to differentiate and to develop between them a middle cell-layer (mesoderm). The ontogenesis of the plant-like animals and worms plainly teaches us that this middle germ-lamella is constantly derived as a secondary product from one of the two primary germ-lamellæ, or perhaps from both simultaneously. One or both of the primary germ-lamellæ must, therefore, necessarily undergo a differentiation in the production of the mesoderm, and can consequently be no longer exactly compared with the two unaltered and permanent germ-lamellæ of the Gastraeada and Sponges (exoderm and entoderm). They must now, like the mesoderm-layer itself, rather be distinguished as secondary germ-layers.[1]

[1] The primitive homology of the gastrula in all the different animal groups, from the sponges to the Vertebrata, from which we directly infer

4. The Phylogenetic Signification of the Four Secondary Germ-Lamellæ.

Whereas the homology of the two primary germ-lamellæ with the exoderm and entoderm of the gastrula, and their phylogenetic identity in all the groups of animals (except the Protozoa), may be accepted with tolerable certainty, on the other hand, the comprehension and interpretation of the so-called mesoderm, or of the middle (third) germ-lamella, and of all the parts which spring from this between the two primary germ-lamellæ, is still subject to many doubts. The contradictions which exist, in this respect, between the different authors are so great and fundamental that it is altogether impossible, in the present condition of ontogenetic literature, to bring them into agreement. Not only is the origin and further development of the middle germ-lamella quite differently described in the different groups of animals, but even in one and the same animal (for instance, in the common hen or in the trout) different observers affirm completely opposite facts with equal certainty. One author makes the mesoderm to proceed from the lower germ-lamella just as positively as a second author makes it proceed from the upper germ-lamella; a third author thinks that one part of the mesoderm arises from the lower, and another part from the upper germ-lamella ; while a fourth author actually makes a portion of the middle germ-lamella, or perhaps even the whole, wander inwards "from the outside!" from the unorganised nutritive yelk. Even if we wish to make excuses for a large part of these irreconcilable contradictions on account of the difficulty of observation, yet the larger portion is certainly due only to the

the true homology of the intestine in all these animals, and their common descent from the Gastraea, is of such importance, that I will at least reply to the most important of the objections which may be raised against it. These objections concern the apparently very different origin of the gastrula from the morula. In most cases a globular cell-vesicle arises from the morula, the wall of which is formed by a cell-membrane. As this vesicle inverts itself at one point, it forms a cup with two surfaces. If this inversion is complete, so that the invaginated portion (entoderm or gastral layer) attaches itself on the inside to the outer, uninvaginated portion (exoderm or dermal layer), the gastrula is complete. This seems to be the original manner of the formation of the gastrula. On the other hand, in other cases the morula hollows itself out internally, and the central hollow (stomachic cavity), the wall of which consists of two layers, subsequently breaks through externally (oral opening). This mode of formation of the gastrula seems to be abridged from the first by inheritance. The result is just the same in both cases, and the apparently significant difference of the genesis is secondary, and to be considered as the result of adaptation, as Ray Lankester (l. c., p. 330) has very well shown.

careless or unmethodical methods of the observers. It is just in the ontogenesis of the mesoderm that it strikingly appears how necessary for ontogenetic investigations is it to constantly look to comparative anatomy and phylogenesis.

In order to overcome the difficulties which the origination of the middle or motor germ-lamella really presents, it may be advisable, first of all, to separate from the beginning the two really different substances of which it subsequently appears to be composed, namely, first, the outer lamella: Baer's muscular layer, Remak's cuticular layer; (better fibrous cuticular layer) or the muscular cuticular layer (parietal layer of the mesoderm); and, secondly, the inner lamella: Baer's vascular layer, Remak's intestinal fibrous layer or muscular intestinal fold (visceral layer of the mesoderm). There are very important reasons for supposing that these two lamellæ are phylogenetically originally distinct, although they appear ontogenetically in many animals as secondary differentiations of an apparently simple middle lamella. This view was already maintained by Baer, who makes the two primary germ-lamellæ divide each into two lamellæ. From the division of the outer or animal germ-lamella arises the cuticular layer, and the muscular layer; from the division of the inner or vegetative germ-lamella arises the vascular layer, and the mucous layer. But this view was subsequently almost entirely abandoned, and it was believed that at first, a third central lamella arises from one only of the two primary cell lamellæ, and that the "muscular layer" and the "vascular layer" are products of the division of the latter.

In any case the first appearance of the mesoderm seems in the Vertebrata to be indistinguishable, so that its entire cellular mass must be derived form one of the two primary germ-lamellæ. Only the fact that some of the more reliable observers derive the middle lamella from the upper (animal) cell lamella, while others derive it, in one and the same vertebrate animal from the lower (vegetative) cell lamella, with equal positiveness, gives rise to the suspicion that both the primary germ-lamellæ subdivide for the construction of the middle germ-lamella. This suspicion becomes almost a certainty by a comparison with the development of the mesoderm in the different Invertebrata, where, in many cases, only the cuticular muscular layer is developed from the upper germ-lamella, whereas the intestinal muscular layer is developed from the lower germ-lamella. Among many observations relating to this, those of Kowalevsky on Euaxes are especially significant. (Petersb. Mem., 1871, vol. xvi, No. 12, pp. 16, t. III). There are also numerous very recent observations on Vertebrata, which

appear to show that the same method of development occurs originally and primarily in them, and that the union of the two muscular layers in the simple middle germ-lamella is a secondary occurrence, while the consequent division of the latter into the two first is a tertiary process (vide Pl. VII, fig. 11—16, with explanation). In connection with this subject the closest examination of the processes in the axial parts of the vertebrate germ-lamella seems to be specially important. Here all the cell-layers appear to be very early already more or less intimately united to the undifferentiated cell mass, which His designates by the name of the axial cord, and which he considered with the germ-lamella to form part of the original coverings of the embryo. This last view is certainly quite false. For the division of the two primary germ-lamellæ is above all things originally complete, as we learn by comparing the gastrula in the different groups of animals; and their union in the axial cords of the Vertebrata is to be regarded as a secondary coalescence. But it appears to be a very important observation that this axial cord is composed of cells of the lower and upper germ-lamella, and that it furnishes cells for the lower as well as for the upper lamella of the mesoderm. The fact is also very suggestive, that a horizontal division of the side layers, which extend nearly to the axis, takes place also very early indeed, in many Vertebrata just after the separation of the chorda from the side-layers, and even before the differentiation of the layers of the rudimentary vertebræ. In any case this separation of the mesoderm into two middle layers vanishes again during the separation of the layer of the rudimentary vertebræ; but it is perhaps to be regarded as a precursor of the later permanent separation of the side layer. As decidedly of importance for this question, I might quote the observation of Kowalevsky, according to which only the dermal muscular layer in Amphioxus undoubtedly arises from the outer, while the intestinal muscular layer arises from the inner germ-lamella. Both muscular layers are here completely separated originally (l. c., p. 6, t. ii, fig. 20). Comp. Pl. VII, fig. 13.

If we examine this difficult problem by the light of the 'Theory of Descent,' it appears to be most probable that the cells of the intestinal fibrous layer or of the intestinal muscular layer are developed from the cells of the gastral or vegetative lamella in a similar manner to that in which the cells of the dermal fibrous layer or of the dermal muscular layer are originally formed from the cells of the dermal or animal lamella. For the last process the important discovery of Kleinenberg is highly significant, according to which the

muscular threads of the Hydra (the first beginning of the mesoderm) do not become independent cells, but remain as only thread-like processes of the nervous cells of the outer cell-layer, the "neuro-muscular cells."

It is not intended to imply by this that the mesoderm is always originally composed of these two layers. As both muscular layers subsequently arose independently of each other, the dermal—the cuticular muscular sheath—as an organ of departure for the skin; the gastral—the intestinal muscular sheath—as an organ of departure for the intestine; therefore the case is also phylogenetically conceivable that only one of the two developes itself. This is actually the case in some Hydroida, and probably in the majority of the Acalephæ; the intestinal muscular layer is here absent and the entire mesoderm is a product of the exoderm, and, therefore, with all its parts, corresponds only to the cuticular muscular layer.

As the two muscular layers in the axial portions of the body cohere at first in the Vertebrata, and only separate afterwards, we can explain, by a very old process of growth, the four originally separated secondary germ-lamellæ, which are found in the axis of the body in the oldest Acrania, and stand in original connection with the origin of an inner central axial skeleton (the chorda). As the germ-lamellæ are already early intimately connected in the "axial cord," from which results many an ontogenetic obscuring and abridgment of the original phylogenetic processes, it indicates also the very early differentiation of the chorda and many other special processes, which occur early in these axial portions of the body. On the other hand, we can satisfactorily explain, not only many of these peculiar processes, but also the contradictions of most authors by the view that this central "axial cord" is a secondary process of growth, and that subsequently both primary germ-lamellæ (in the five higher groups of animals) take part in the composition of the mesoderm.

By this view the origin of the body-cavity can be very easily physiologically explained. It can be pictured quite mechanically as soon as it is remembered that the two muscular layers just developed have a simultaneous action independently of each other. A division is then necessarily produced between the two, and fluid collects in the cavity thus formed. This fluid transfuses through the intestinal wall into the primitive body-cavity, and is the first blood, and separate cells of the intestinal fibrous layer, detached during the transudation, which remain in this primitive blood-fluid and multiply, are the first blood-cells.

The true body-cavity of animals, the cœlom (or the so-called "pleuroperitoneal cavity"[1]) has, therefore, also arisen phylogenetically in a similar manner by the two muscular layers or middle germ-layers shrinking apart, as is known to be the fact ontogenetically, since the time of Remak, in the embryology of Vertebrata. The mesentery is formed where the two layers remain in connection, and keep the intestine firmly attached to the body-wall. I have already fully detailed my morphological idea of the body-cavity in the 'Biology of Calcareous Sponges' (p. 467), and, therefore, content myself here with again expressly making it prominent that, according to my view, the cœlom has first arisen in the Vermes by the above-mentioned process (shrinking apart of the two muscular layers), and has been transferred as an inheritance from these to the four higher groups of animals. On the other hand, the cœlom, or true body-cavity, is absent in all the Zoophyta (sponges and Acalephæ), as well as in the lowest worms, the Plathelminthia (Turbellaria, Trematoda, Cestoda). With the cœlom, the blood, and the vascular system is at the same time absent in these animals, for these parts are inseparably united. Where the first trace of true body-cavity appears, the first blood is also already present, namely, the secretion which fills the latter, the primitive "Hæmolymph" or "Hæmochyle."

This view of the cœlom places me in direct antagonism with the view of Leuckart, already shared by most zoologists, who attributes to the Zoophytes (his Cœlenterata) a true cœlom, and as late as 1869 represented his opinions thus: "The body-cavity of the Cœlenterata does not lie between the exoderm and entoderm, but is enclosed by the latter,[2] just

[1] The technical term *cœlom*, which I have proposed in the 'Biology of Calcareous Sponges' (p. 468), for the true body-cavity of animals, is preferable to the hitherto customary expression "pleuroperitoneal cavity," not only on account of its greater shortness and convenience, but, before all, because the other term is not applicable at all in a strict sense to the Invertebrata, and applies to the latest and most differentiated condition of the cœlom, as it occurs only in the highest Vertebrata.

[2] Leuckart says (in the 'Archiv für Naturgeschichte,' 1870, II, p. 270), "The opinion that the inner hollow structure of Cœlenterata corresponds in its morphological significance to the body-cavity of other animals, has met with pretty general acceptance in our science—a view which anatomical relations not only justify, but also compel the observer to agree with," &c. In reply to this we may remark that Van der Hoeven characterised the Acalephæ twenty years ago in his 'Natural History' (furnishing corrections to Leuckart) quite correctly in the following words:—"Ventriculus parenchymato corporis *sine cavitate abdominali* inclusus: canales e ventriculo ortum ducentes." Gengenbaur (1861), Noschin (1865), Semper (1867), and Kowalevsky (1868), have subsequently in the same sense correctly

as little can I share the opinion of Kowalevsky, who declares the invaginated cavity or segmentation cavity to be the first trace of the body-cavity. I can only perceive in the hollow which is formed during the grooving between the furrowed cells, and which afterwards forms the hollow of the germinal vesicle (vesicula blastodermica), a casual hollow without any permanent morphological signification. It, indeed, always disappears again in the course of ontogenesis, and never passes directly into the true cœlom. This last makes its first appearance much later, as a really new formation, a division between the two muscular layers. According to Kowalevsky's view, the cœlom would be phylogenetically much older than the intestinal cavity, whereas the reverse is actually the case. The intestine has certainly existed very long as a primitive organ in the Zoophyta and Acœlomi, before it developed (in the Cœlomati) the true body-cavity between the intestinal wall and body-wall.

(*To be continued.*)

Atmospheric Micrography, by the Rev. M. J. Berkeley, M.A., F.L.S.

Since Ehrenberg's remarkable treatise on the 'Dust of the Trade Winds,' numerous observations have been made on the various substances which float in the atmosphere, either in connection with their supposed influence in the production or promotion of disease, or with reference to the great controversy respecting spontaneous generation. These observations were, however, frequently made in utter ignorance of the true nature of the organisms in question, or with strong prejudices in favour of some particular theory, in aid of which they were interpreted. It became part of the duties of Dr. Cunningham and Dr. Lewis, who were sent to India by our Government to investigate thoroughly everything which might throw light on the origin of cholera and other formidable diseases to which our Eastern possessions are especially subject, and from which one of the most formidable in other countries certainly originated, amongst other matters, to see what was really carried about by the winds, and the results of the inquiry which more peculiarly fell to the share of Dr. Cunningham are certainly most extraordinary.

regarded the cœlenteric system of cavities in the Zoophyta as an intestinal cavity.

The pains which he has taken to collect all accessible previous information on the subject, and the entire freedom from all prejudice, added to an accurate knowledge of the minuter forms of vegetation and of animal organisms, are amply manifested in the valuable treatise which has lately been received in this country from Calcutta.[1]

The work commences with a review of the literature of Atmospheric Micrography, the necessity for which is thus stated: "Similar observations have been previously recorded by numerous other authors, and before proceeding to those forming the subject of the present report, it may be well briefly to review the literature relating to them, with a view to ascertain what our knowledge of the question really amounts to. It is the more desirable to do this as no general summary of the kind has, as far as I know, ever been attempted, and the information is scattered through scientific journals and the transactions of learned societies in isolated papers, many of which are, when taken separately, likely to lead to very imperfect conceptions regarding the subject as a whole. In attempting anything of this kind I am well aware that the result is likely to contain numerous omissions and other imperfections, more especially in a country such as this, where there is great difficulty in obtaining access to the requisite information, but, such as it is, it may yet be of use in rendering the latter part of the report more intelligible than it might otherwise be, and in facilitating an estimate of the value of any conclusions there stated. A chronological order has been as much as possible adhered to, the first observation recorded by any author being taken as a starting point for a sketch of his after work; and where this is not so, or when due prominence does not seem to have been given to any set of observations, the error is to be entirely ascribed to lack of information, and not to any desire to undervalue or neglect any one's work."

The observations were made at the two large jails in Calcutta, with the view of determining, if possible, whether there were any connection traceable between the prevalence of any special bodies in the atmosphere, and the occurrence of particular forms of disease. They were fifty-nine in number, the date of the first being the 26th of February, and that of the last the 18th of September, 1872.[2] The apparatus was a

[1] 'Microscopic Examinations of Air,' by D. Douglas Cunningham, M.B., Surgeon H.M. Indian Medical Service (on special duty), attached to Sanatory Commissioner with Government of India. Calcutta, Fol. p. 78, tab. xiv, Diag. iv, fig. 10.

[2] The climate at Calcutta is very dry from the former date to the begin-

modification of that employed by Dr. Maddox, the whole turning freely, so as to present its orifice constantly to the wind, the particles impinging on a vertical slip of microscopic glass painted with glycerine, and capable of being transferred without danger of their being rubbed off, to the table of the microscope, care being taken that everything was made previously as clean as possible.

In the Presidency jail the apparatus was placed within the largest enclosure, on an open space of grass, to the east of a large tank in which the native prisoners bathe. The most convenient locality at Alipore was to the north of the hospital-tank, between the compound of the jail and the tidal nullah, from which it was separated by the wall of the enclosure. The diaphragm was removed every twenty-four hours. The magnifying power was in general 400 diameters, but higher powers, ranging from 800 to 1000 diameters, were used for more minute bodies. Dust from shelves of iron or stone was purposely excluded, as algæ or other bodies might have grown up from particles conveyed from the soil, rather than from the atmosphere. The mouth of the apparatus was about five feet from the ground.

On microscopic examination the deposits were found to consist of various matters.

1. Particles of silicious matter.
2. Particles of carbonaceous matter.
3. Fragments of hair and other animal substances.
4. Fragments of cellular tissue of plants.
5. Pollen grains, amongst which those of several common grasses could be easily recognised,[1] and a few belonging to

ing of June, and more or less wet to the beginning of September, which accords with the dates appended to the figures.

[1] This may be of importance after the very interesting observations of Mr. Blackley on the connection between the pollen grains of grasses and hay asthma. [A brief record may be given here of Mr. Blackley's results. They were commenced in April, and continued till the end of July. In one series the air of a meadow at the average breathing level, 4 feet 9 inches from the ground, was examined. A slip of glass, coated with a thin layer of a non-drying liquid, was exposed horizontally. The daily results are tabulated. The highest number of pollen grains obtained on a surface of a square centimètre in twenty-four hours was 880 on June 28. Sudden diminutions in the quantity of pollen—when these occurred in the ascending scale between May 28 and June 28—were invariably due to a fall of rain, or to this and a fall in the temperature combined. The amount of pollen in the higher strata of the atmosphere was examined by means of a kite, which by being attached to other kites sometimes attained an elevation of 1000 feet. Pollen was found to be much more largely present at the upper levels than at the "breathing level," in the proportion, in fact, of 19 to 1. Abundant proof was also obtained of the presence of fungoid spores in

plants of other natural orders. It is not certain that any seeds of Phanerogams reached the diaphragm, though one or two of the figures, except for their small size, might at first seem to intimate as much.

6. Algæ. These were, in comparison, few in number, but besides those lower genera which appear to be early stages of lichens, there were undoubted fragments of *Oscillatoriæ*, as in t. iv, fig. 2, t. viii, fig. 4, of *Desmidiaceæ*, as in t. v, fig. 1,[1] of *Closterium* in t. xii, fig. 3, and apparently of Diatomaceæ in t. i, fig. 4. These latter are, however, if present at all, extremely rare.

7. Sporidia of lichens are frequent.

8. Far the greater part of the bodies are spores or sporidia of fungi, often at once referrible to their proper genera. Spores of *Macrosporium*, and one or two allied genera are extremely common. *Cladosporium herbarum*, one of the most universally diffused fungi, appears in one case with a spore *in sitû*. *Helminthosporium* is represented (apparently *H. Smithii*) in t. viii, fig. 1. *Sporidesmium* is not unfrequent. True Torulæ do not appear to be present, but the yeast fungus, which, after proof that it is nothing more than a condition of common species of *Penicillium*, *Aspergillus*, and *Mucor*, is so often referred to *Torula*, or to Algæ, frequently occurs, either in scattered particles, or branched. A young *Mucor* with its sporangia is visible in t. ii, fig. 3. The curious genus *Tetraploa*, which has occurred once only in England and once in Cuba, is not unfrequently represented, most probably being not uncommon on some of the native grasses, and *Triposporium* appears in t. vi, fig. 2. Spores of *Uredineæ* are frequent, *Puccinia*, except in an early stage, much less so. Far the most common bodies are sporidia of *Sphæriaceæ* frequently in a state of germination, both in dry and hot seasons. So little is known of the species belonging to this order of fungi in the neighbourhood of Calcutta, that they cannot with certainty be referred to their proper group, much less to their

large quantities in the air. In one experiment the spores of a cryptogam, at 1000 feet, were so numerous that they could not be counted; at a rough estimate they could not be less than 30–40,000 to the square inch. That these organized contents travel through the air to a considerable distance was proved by a series of experiments made in the outskirts of Manchester, but within the boundary of one of the most densely populated parts, and in no direction within less than one third of a mile of grass land. The quantity of pollen was about one tenth of that collected in the country.—'Experimental Researches on the Causes and Nature of Catarrhus æstivus,' by C. H. Blackley, 1873.—Eds.]

[1] At least, the lower figure seems to suggest as much.

species, nor is it certain that they are derived from the immediate neighbourhood. It is very probable that several of the bodies are spores of *Myxogastres*, the amœbæ which appear in certain specimens of pure rain water, being very probably the mere development of *Myxogastres*-spores, in accordance with the well-known observations of Prof. de Bary. It would be easy to point out many which are more probably referrible to *Myxogastres* than to any other fungi. Spores of some of the higher[1] fungi may possibly be intermixed, but their structure is in general so simple that they are not easily recognized. In one instance, however, in the miscellaneous observations recorded in Section III, fig. 4, there is apparently the germinating spore of *Tremella* or some neighbouring genus. The extraordinary quantity of fungus spores carried about by the air is very remarkable, and the more so, when contrasted with Ehrenberg's observations of the dust of the trade winds.

It is necessary to take notice of some observations which were made on matters contained in the air of sewers, care being taken that there was no communication with the outward air. Many years since Lord Sydney Godolphin Osborn made a very praiseworthy attempt to ascertain what bodies might be derived in the air from the mouths of sewers. These observations were communicated to 'Household Words.' It is, however, obvious, that the plan then adopted would not insure the derivation from the sewer, as similar bodies might be conveyed from the external air; peculiar cautions, therefore, were taken to avoid this uncertainty. The results were very different from the open-air observations. The only spores (with very few exceptions, and those far from certain) which appeared, were those of *Aspergillus* and *Penicillium*, which were developed abundantly on the walls of the sewer, and these in four out of eight experiments were accompanied with bacteria. Oily particles were frequent, and fine molecular matter of an uncertain nature, in addition to small quantities of carbonaceous and silicious particles, and a few minute portions of cellular vegetable tissue.

The following observations on the presence of bacteria are important, as not opposed to the atmospheric transmission of these organisms:—" The existence of distinct bacteria in half of the specimens is also very worthy of consideration when the extreme rarity of such organisms

[1] In two melted flakes of snow from Highgate sent to me mounted on slides many years since, there were undoubted spores of fungi, some of which were possibly referrible to higher fungi. All were perfectly colourless and transparent.

in a recognisable form as a constituent of common atmospheric dust is recollected. Their presence here accords with Cohn's observation on their conveyance by watery vapour, and suggests that their apparent absence in ordinary atmospheric air is due, not to their not entering in it in large quantities, but to the fact that unless the amount of watery vapour present is very great they lose their characteristic appearance, by which, in default of movement, they can only be recognised" (p. 52). The addition of dry dust to fluids capable of undergoing putrefaction was followed by their copious appearance, and they also were met with in pure rain-water. It might, however, have been expected that they would have appeared at the commencement of the rainy season, which is generally preceded by a peculiar vaporous condition of the air in many parts of India, but whether this is the case at Calcutta there is no means at present of ascertaining.

It is not necessary to give at length the general conclusions here, and, indeed, most of them have been anticipated above. The main and most important is the following:—"No connection can be traced between the numbers of bacteria, spores, &c., present in the air and the occurrence of diarrhœa, dysentery, cholera, ague, or dengue, nor between the presence or abundance of any special form or forms of cells and the prevalence of any of these diseases."

In a more strictly botanical point of view the occurrence of such numerous fungus-spores of such various kinds, in a situation where they could scarcely have been suspected to be present, and the fact of so many of them being in a state of germination is most interesting. It is impossible to say from whence the greater part of them were derived, but one understands at once how it is possible that the same fungus may occur in very different latitudes, provided the climatic conditions are sufficiently favorable.

It is possible that some of the spores may have germinated on the diaphragm during the twenty-four hours in which it was exposed to the air, but, as Dr. Cunningham says, it is impossible to think that this is the case in such preparations as t. xii, fig. 2, and he believes that germination may take place while the spores or sporidia are wafted through the air. And this is the more probable, as they would very rarely be taken up in such a condition. If this be true the germs would settle on their proper matrix in a condition most favorable for immediate propagation.

Some interesting observations were made on the organisms which appeared in rain-water at Calcutta, algæ

forming, as might be expected, a more decided feature than in the deposits derived at once from the air. The conclusions at which Dr. Cunningham arrived are the following:

1. Specimens of rain-water in Calcutta, collected with every precaution to ensure their freedom from contact, contamination, sooner or later, frequently show the presence of spores, mycelium, zoospores, monads, bacterioid bodies, and distinct bacteria.

2. They do not, as a rule, contain any of the higher forms of infusoria.

3. The zoospores are demonstrably derived from the mycelium arising from common atmospheric spores.

4. There is every probability that the monads and bacteria have a similar origin, but it remains quite uncertain whether their development is due to heterogenesis or to the presence of their germs within the parent cells, or as the result of a process of normal development in the latter.

The above is but a slight sketch of a most interesting memoir, every page of which deserves careful attention.

REVIEW.

The Microscope and Microscopical Technology. By Dr. H. Frey, translated by G. R. Cutter, M.D., from the fourth German Edition. New York, 1872. London, Sampson Low and Co.

The admirable text-book of Professor Frey is too well known to require any lengthened eulogium at our hands. It has long been familiar to all histologists acquainted with the German language, and we must now congratulate English readers on having it presented in a form accessible to them.

Dr. Frey follows the practice of other writers on the microscope in prefixing a general account of the instrument itself, and the methods of observing with it. This appears to us to be the least satisfactory portion of the manual. The optical part is, perhaps, sufficient, but barely so; that relating to the use and manipulation of the microscope is in several respects defective. For instance, in the case of "correction" for thickness of cover-glass some description is given of the apparatus, but it is hardly explained, and no practical directions for using it, so that a student relying on Professor Frey's instructions would find himself much at a loss, or obliged to use his "correction" by mere guesswork. The subject of illumination is also treated in a very cursory manner, some of the English condensers being figured, but not explained; and though this, of course, is a less important matter in Germany, where artificial light is more rarely used than with us, still some of these contrivances are practically indispensable for displaying the minutiæ of high-power definition, which Professor Frey afterwards shows that he does not despise.

It was, of course, natural that English microscopes should receive little notice, since the work was originally intended for German observers and students. The translator has hardly supplied this deficiency, even for American readers, by his lengthy account of the history of microscope-making in the United States.

There is a tolerably full account of test objects, and their influence in the improvement of the microscope. The author

disclaims (and we think with good reason) an unreasonable contempt for these minutiæ. Doubtless a great deal of time has been wasted in "resolving diatoms," and if that were an end in itself, it would be a very poor one; but there can be no question that these minute observations have done much to stimulate the energy and skill of microscope makers. Moreover, microscopes are actually corrected—that is, virtually made—by the help of these test objects. Herein lies the fallacy pointed out by Dr. Royston Pigott; the instrument is made to show a certain appearance (such as exclamation marks on the Podura scale), and altered if it does not show it. Of course, then, it will always exhibit the same structure, but the value as an independent test is gone, since we do not know that the appearance may not depend on some fault in the glass which we go on perpetuating. This source of error is not noticed by Professor Frey, but he gives one additional test, too little used by our makers, namely, Nobert's lines. Even these, however, test one quality only of a microscope. The only really independent test is that suggested by Dr. Pigott, the image formed by the microscope of a known object visible with the naked eye. Here we have at once a standard of comparison, and the photographic achievements of our American colleague, Dr. Woodward, remove another element of much uncertainty, the interpretation of observations with a view to their representation.

These data supply the bases for a really scientific system of testing microscopes, which has yet to be constructed.

Perhaps the most valuable portion of Professor Frey's work is that relating to the methods of preparing histological objects, and the various sections on staining, injecting, and mounting. For the purposes of the medical student and histologist there is no doubt that this is by far the most useful and complete body of instruction that has ever been put together; it stands, indeed, without a rival. The happy eclecticism of the writer preserves him from the one-sidedness which is the great defect of some of our English text-books; and though his own technical skill is well known, he has not been unwilling to receive hints from all quarters.

It is, of course, impossible to notice the multifarious topics of this part in detail; but we may note in passing that Dr. Frey still looks upon carmine as the best colouring material, and, for permanent preservation of objects, upholds Canada balsam in preference to dammar or other substitutes lately recommended.

He also shares the distrust of many skilful histologists for mechanical appliances intended to come in aid of manual

dexterity, and objects to all forms of section-cutters or microtomes, of which he gives no description. The American translator has, however, inserted a description of a section-cutter invented by Dr. Edward Curtis, of New York, which resembles, in the main, the instrument of Drs. Stirling and Rutherford, but without the freezing apparatus, and having this peculiarity, that the knife is held in a frame, which elevates it slightly above the table of the "holder," in which the object to be cut is contained. The table is, moreover, made of glass, an improvement recently suggested by Mr. Needham in the English microtome.

The remaining part of Dr. Frey's work is devoted to special histological methods, and will be found most useful by workers at normal or pathological histology; for botanists and zoologists it is, of course, less suited.

The translation is, on the whole, fairly executed, though we think the principle of literalness has been carried to excess, and has certainly often involved a sacrifice of elegance as well as sometimes of clearness. With regard to the form of the book, we must only regret that it has not been found possible to make it smaller and less expensive.

NOTES AND MEMORANDA.

A Finder for Hartnack's Microscopes.—In working with one of Hartnack's microscopes, I found an inconvenience which must have been felt by others, from the impossibility of adapting any one of the ordinary finders to a stage so simple in construction. Bridgman's finder, as described, p. 43, of Beale's "*How to work the microscope,*" at first suggested itself as available; but this is clearly suited only to microscopes having at least a sliding movement to the stage, unless two are employed, one on each side of the stage.

The following contrivance will, I think, meet every requirement. A line is ruled across the centre of the stage from side to side, crossing this line at right angles are ruled two lines about two inches apart, one on either side of the central aperture of the stage. In order to use the finder, it will be necessary to have a small white label affixed to each end of the slide, the most convenient size being a round half inch label. The portions of the lines on the stage left uncovered by the slide being used for guidance, corresponding lines are continued across the labels on the slide with a pencil mark. Thus, at each end of the slide a cross-mark will be formed, and whenever the cross-marks on the slide are made to coincide with the crossing of the lines on the stage, the part of the object required is in the field of the microscope.

This plan answers very well, but I was enabled to render the effectiveness of the arrangement almost equal to the graduated stages of the larger microscopes for accuracy in finding, by the following very simple device. I roughened each end of the slide by means of a corundum file and some water, so that that the lines on the stage could still be seen through the ground glass ends, and the points where they cross marked on the slide with a pencil or ink spot. Many points may thus be registered on the same slide.

Not only are the ground glass slides useful for this purpose, but I think they will serve a much more valuable pur-

pose to all miscroscopists, by enabling them to label all slides at once with the minimum expenditure of time and trouble.

I tried, but without success, to discover where a sand-blast for etching glass was to be found in operation; for this would obviously be the most simple means of roughening the ends of the slides. FREDERICK J. HICKS.

The Potato Disease.—From a statement in the 'Agricultural Gazette' (February 7th, 1874, p. 185), a sum of £100 appears to have been granted to assist Professor de Bary, of Strasburg, in the investigation of the life-history of the potato-fungus (*Peronospora infestans*). In the next number an explanation was published (p. 210) from Mr. Jenkins, the Secretary of the Society, of the grounds which had induced the Council to take this step. It is as follows:

"The scientific aspect of the potato disease also received the careful attention of the judges of the essays, and in their report to the Council they expressed their regret that no essayist appeared to be acquainted with the most recent discoveries in that field of inquiry. They *therefore* recommended the Council to grant a sum of money for the purpose of inducing a competent mycologist to undertake a special investigation into the life-history of the potato-fungus. The Council have adopted this course also; and it is most gratifying to be able to announce that Professor de Bary, of Strasburg, the highest living authority on the fungi of our farm crops, and *especially* on the potato-fungus, has undertaken this important investigation."

It may be interesting to recapitulate the present state of our knowledge of the *Peronospora*. It was first described by Montagne in 1845. In the following year Berkeley published a paper in the 'Journal of the Horticultural Society,' in which he gave the drawings which Montagne communicated to him for the purpose, in addition to those of himself and Broome. At that time Berkeley in this country and Morren in Belgium stood alone against the whole weight of eminent botanical authority, in regarding the *Peronospora* as the cause, and not the effect, of the potato disease. This paper established the general habit of the fungus, and also described its asexual spores.

In 1854 Tulasne published in the 'Comptes Rendus' his discovery of the oospores or resting spores resulting from the sexual reproduction of the *Peronosporeæ*. Down to the present day, however, this has never been verified in the case of *Peronospora infestans*, although Berkeley, as long ago as 1857, suggested that a fungus described by Montagne in

1845, under the name of *Artotrogus*, might be this second form of fruit.

In 1861 De Bary published an investigation of the potato disease, in which he described for the first time the mode in which the filaments of the germinating spores penetrate the potato plant. About the same time he also announced that the sporidia (which had been first detected by Montagne) of the *Peronospora* were ciliated—were, in fact, zoospores. Prévost, however, had discovered zoospores in the nearly related genius *Cystopus* in 1807.

In 1863 De Bary published an elaborate memoir 'On Parasitic Fungi,' in which the history of the *Peronosporeæ* was carefully investigated. No one, however, has succeeded in detecting the sexual mode of reproduction of the species which infests the potato, and it remains to be seen whether Professor de Bary will obtain under the auspices of the Royal Agricultural Society the information on this important point which has hitherto eluded him. While all botanists will look forward with interest to Professor de Bary's report, it seems almost a matter for regret that the Society did not endeavour simultaneously to enlist the aid of some English microscopists in the investigation. It would, perhaps, have been possible for the Council to request the botanical adviser of the Society, who would necessarily be versed in "the fungi of our farm crops," to report upon the subject, and to associate with himself some of the not undistinguished cryptogamic botanists of this country, with a view of organizing during the present year a systematic plan of investigation of the resting stage of this terrible parasite.

Mounting in Balsam.—Mr. W. H. Walmsley's success in mounting objects gives great value to his practical suggestion contributed to Science Gossip. He regrets that beginners should be confronted with spring clips, spirit lamps, and over-heated balsam, when balsam, dried to the point of brittleness and then dissolved to the consistency of rich cream in chemically pure benzole, would obviate the necessity for such annoyances. He frees the specimen from moisture by drying, or preferably by passing successively through weak and absolute alcohol, treats it with oil of cloves which is more desirable than turpentine because more readily miscible with balsam, and not calculated to harden the specimens even if they are left in it for a long time, transfers it to the slide, and arranges it with needles, places a drop of the balsam solution on it and applies the glass cover in the usual manner. In a few days the mount will be sufficiently hardened to be handled with safety, espe-

cially if after twenty-four hours it should be slightly warmed, and the cover carefully pressed down with the forceps, and held down with a small weight. The best finish for the edge of the circle he finds to be the same balsam that is used in mounting, laid on with a camel's hair pencil; since this is neat and handsome, and will not spoil the specimen by running in, as may happen with coloured varnishes.—*American Naturalist*

An aid to Microscopical Drawing.—I wish to call the attention of those interested in microscopical work to a modification of the existing apparatus used for microscopical drawing. The instrument I use and find more useful than any other for this purpose, on account of its simplicity and the ease with which it is worked, consists of the thinnest possible covering glass placed at a proper angle in front of the eye-piece. The advantage of this thin film of glass over the camera lucida, the neutral tint reflector or the steel disc, is that it enables the pencil to be easily followed in tracing the image which is thrown upon the paper below. An ordinary piece of white glass does not answer the purpose, as it throws two pictures of the object. This doubling of the image is reduced to nothing in proportion to the thinness of the glass. The instrument which I have had made for me by Mr. Sutton, instrument maker, 108, Holloway Road, cost the moderate sum of three shillings and sixpence. It is composed of a brass collar (to affix to the eye-piece of the microscope) to which are attached two light brass arms, between which revolves the glass, so that it may be placed at the required angle.—W. Kesteven, Jun.—*Lancet.*

Cryptogams in the Interior of Eggs.—Professor Panceri made a communication to the Institut Egyptien at its meeting on December 13th, on the cryptogamic vegetation which he had found within the egg of an ostrich. This egg had been given him at Cairo, and was still fresh, the air space having not even been formed. He soon, however, noticed the appearance of dark blotches within the shell, and having broken it open to ascertain the cause, he found that they were produced by the growth of minute fungi. Instances of a similar kind had already been studied by him, and he had communicated the results to the Botanical Congress held at Lugano, in 1859. The believers in the reality of the spontaneous generation of living organisms have not been slow to seize on these cases as an argument in their favour, since *á priori* it would seem that the shell of an egg would be quite impermeable to germs derived from without. Panceri has succeeded in satisfying himself, how-

ever, that the unbroken shell of an egg is permeable to liquids, and that these may introduce germs into its interior. He has, in fact, actually inoculated uncontaminated eggs with a fungus which he had obtained from the interior of one in which it had made its appearance in a way apparently so mysterious, and had cultivated in egg albumen.—*Academy*. [The Rev. M. J. Berkeley states that he has found *Cladosporium herbarum*, in the interior of ordinary fowls' eggs.]

Supposed encysted Entozoon with ova.—Dr. Maddox's account of the occurrence of an encysted entozoon with ova, in the muscles of a sheep noticed in our last volume (p. 302), is seriously questioned by Dr. Cobbold, who thus writes in 'The London Medical Record' (p. 487, 1873).

It forms an important contribution to our knowledge of the structure of the mutton measles (*Cysticercus ovis*, T. S. C.); but the author has, without doubt, fallen into errors of interpretation, which are too important to be passed over without comment. The entozoon in question is clearly the same as that which was first described by the writer of this notice at a meeting of the Pathological Society, April 3rd, 1866 ('Trans. Path. Soc.,' vol. xvii. p. 463); other particulars having subsequently been given in the writer's small volume, 'On Tapeworms' (1867, p. 83), and in the supplement to his larger treatise ('Entozoa,' vol. ii. p. 30), 1869). These references appear to have escaped Dr. Maddox's attention, but the actual facts observed by him are particularly valuable, as adding numerous particulars to those already observed.

That we have here a larval cestode entozoon, cystic helminth, small bladder worm, or meat measle shown to be capable of developing ova in its interior is the conclusion arrived at by Dr. Maddox. He has evinced the most painstaking care in comparing the so-called calcareous corpuscles of this cysticercus with the ova of a mature tapeworm; and, notwithstanding the accuracy of his admirably drawn figures, he is perfectly satisfied that his encysted entozoon contains well-formed eggs. Dr. Maddox even ventures (though with evident hesitation, as the marks of interrogation placed here and there imply) to refer to such structures as the intromittent organ, the ovarium, and vitelligene organ.

From Dr. Maddox's own figures, apart from the overwhelming evidence derived from the records of helminthology and personal experiences, the writer of this notice is quite satisfied that the so-called ova are not in reality eggs, but merely large calcareous corpuscles closely resembling them. The cystic entozoon removed by Dr. Maddox from the

muscles of the lower part of the neck, and the 'measle' removed by Mr. Heisch 'from the centre of a mutton chop' ('Entozoa,' *loc. cit.*, p. 30), are clearly referable to one and the same form of armed cestode larva. Setting aside the errors of interpretation above-mentioned, Dr. Maddox's contribution is most interesting, not only as confirming the experiences of three separate English observers (as to the fact of the occurrence of measles in mutton), but as adding numerous and useful microscopic details.

Lostorfer's Syphilis-corpuscles.[1]—The observations of Lostorfer who described certain bodies which he affirmed became developed in the blood of syphilitic persons have been very generally discredited.

Lately, however, Biesiadecki (*Untersuchungen aus dem Pathologisch-Anatomischen Institute in Krakau.* Vienna, 1872), following Lostorfer in a large series of experiments, has come to the conclusion that the assertions of Lostorfer are, with some slight modifications, correct. The mode in which Biesiadecki proceeds in his observations is similar to that employed by Lostorfer. By means of a pointed needle, a small drop of blood is taken from the perfectly clean finger, brought on a clean glass slide, and covered with a glass. By a slight pressure on one edge of the cover-glass with the nail of the finger, the blood can easily be made to spread out so that the blood-corpuscles lie only in one layer, without being broken up and destroyed. Preparations in which the blood-corpuscles have not spread out into one layer, or in which they appear to be squeezed, are to be put aside as useless.

A number of preparations are brought into a moist chamber, where they are kept at a temperature of 14—18° C. (57—64° Fahr.).

In most of the preparations which have not become dry at the edges of the cover-glass, taken either from syphilitic or other patients, *e.g.* arthritic or rheumatic, there appear on the second, third, or fourth day numerous needle-shaped or rhombic hæmoglobin-crystals, varying in diameter from that of a blood-disc to twice or three times as large. In blood-preparations of syphilitic patients the following changes take place, beginning from the fourth day. In the yellowish coloured plasma there appears a cloudy opacity, which is due to the presence of small flakes. These latter are seen to contain extremely small spherical bright granules, which generally possess a filamentous appendix. The fifth day the number of these granules becomes much greater; they become

[1] See 'Quart. Journ. Mic. Sci.,' 1872, p. 169.

much larger, perfectly bright, spherical or irregular-shaped, whereas at the same time the filamentous appendix disappears. These granules make their appearance all over preparations; they are not limited to certain foci. The most of them are to be found on those places in which plasma is still unclosed.

After the twelfth day, up to which time their number has increased immensely, no material change can be made out, even up to the twentieth day, except that some become a little larger, brighter, and more sharply outlined.

In preparations of the blood of patients suffering from different diseases (endocarditis, acute rheumatism, Addison's disease, gout, jaundice, pneumonia, tuberculosis, variola, puerperal peritonitis, septicæmia), the above-described corpuscles make their appearance only in an extremely limited number. Consequently, a preparation of blood which contains only a few of those corpuscles is unavailable for a diagnosis; whereas a preparation that contains a great number of them can be said to have been taken from a syphilitic patient. Biesiadecki succeeded in this respect, just as Lostorfer, in being able to point out in a series of mixed preparations, submitted to him and prepared in the above-mentioned manner, which of them had been taken from syphilitic patients, and which not; except in one preparation, in which Lostorfer's corpuscles were present abundantly, and which was taken from a patient suffering from pustula maligna; it could not be ascertained, however, whether this patient did not suffer from syphilis.

Biesiadecki shows that these corpuscles are not fat, not sarcina, not granules of colourless corpuscles, and not fungi, as Lostorfer was inclined to assume, but that they are granules of precipitated paraglobulin; for, *a.* if a current of carbonic acid be allowed to pass through a preparation of diluted serum (plasma ?—*Rep.*) of a dog, similar corpuscles to those above described make their appearance; on replacing carbonic acid by oxygen they disappear; *b*, if through a blood-preparation, in which numerous syphilis-corpuscles have developed, a current of oxygen be allowed to pass, the small ones disappear, whereas the larger ones diminish considerably in size; *c.* the syphilis-corpuscles do not dissolve in either, but they dissolve almost entirely in a large quantity of saline solution (one part of concentrated saline solution in two parts of water). All these are properties which belong to paraglobulin.

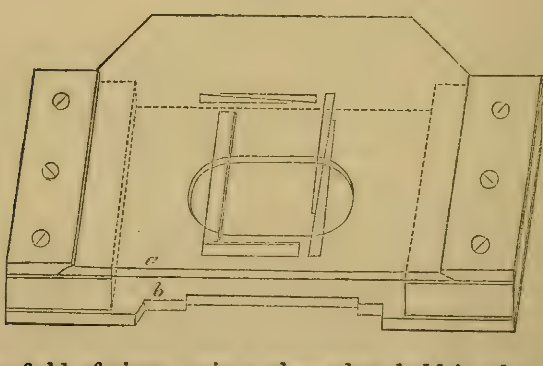
In blood-preparations, therefore, which are kept in a moist chamber, that is, in which, on the one hand, the plasma

becomes gradually diluted by absorption of water, and in which, on the other hand, as it must be supposed, carbonic acid is developed by decomposition, all the conditions are present under which paraglobulin may be precipitated. That Lostorfer's corpuscles are to be met with abundantly generally only in blood-preparations from syphilitic patients, seems to show that their blood contains either more paraglobulin or less fibrinogenous substance than other blood.—E. Klein, M.D., (*in Medical Record.*)

A New Section Cutter.—Professor Biscoe has contrived a new section cutter which is principally adapted for preparing sections of soft vegetable tissues and organs, such as leaves, buds, &c. It consists essentially of a large glass stage-plate upon which the object is fastened, and a movable frame to slide upon this, carrying a razor blade at an adjustable distance from the plate. This apparatus cuts sections of objects while they are under observation on the stage of the microscope, under powers as high as the $\frac{2}{3}$ inch ($\times$ 80); and with it Prof. Biscoe has been able to cut series of fifteen consecutive sections, each one of which was perfect and the average thickness of which was $\frac{1}{8000}$ inch. The following is his description of the contrivance:

Fig. 1 is a plate that fits on to the stage of the microscope with a tight friction, yet so that it has movements of an inch or more in any direction, so that the object can be brought

Fig. 1.



into the field of view; *a* is a glass plate held in place by the two pieces of wood, with screws on the right and left; *b* is the wooden base of the affair with an oval opening for the illuminating apparatus to come up; this wooden base being covered on the inner or upper side with velvet to make smooth

the friction on the under side of the stage. For use with a mechanical stage this arrangement is modified and much simplified, the large glass plate being merely attached to the stage, whose screw movements enable the object to be brought into the field of view. On the middle of the upper side of the glass plate are cemented four strips of glass as shown, just far enough apart to take in a common glass slide, which is held in place by a couple of wedges of common sheet brass; and on the middle of a slide is fastened the object to be cut, either with gum arabic or sometimes with collodion. For holding hard objects like wood the arrangements are not yet quite perfected, but no special difficulty is expected.

Fig. 2 gives a perspective view of the triangular wooden frame that holds a razor blade, *r*, whose edge and back come down lower than the rest of the frame. By means of the three screws with graduated heads the whole frame, razor and all, is raised or lowered from the glass plate (*a*, Fig. 1) on which the triangle rests and slides with these three screws as its feet. These three supporting screws are cut with a thread that counts forty to the inch; the screw head is divided into one hundred equal parts, and can be moved without much difficulty through half of one division, giving a vertical motion of $\frac{1}{8000}$ inch to the cutting edge.

Fig. 3 is a large view of one of the screws, with its indicator. The indicator may be a simple pin set in the wooden frame, but is more convenient if made movable around the axis of the screws, so that when the razor is returned after sharpening they may be all turned around to the 0 of their

FIG. 2.

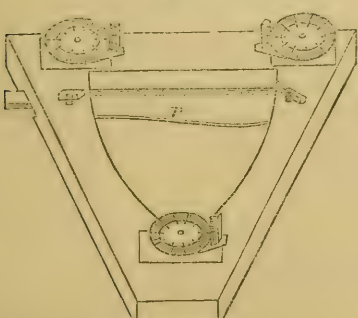
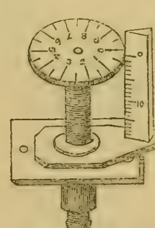


FIG. 3.



respective screws, and therefore all read alike, while the successive cuts are being made. On the side of the indicators are scales which show how many complete revolutions of the

screws have been made. These indicators should move quite stiffly, so as not to be accidentally misplaced when turning the screw heads.

With the hands upon the triangle and the eye at the microscope tube, the razor can be moved so that its edge shall either make a drawing cut or push straight through the object like a chisel, according as either method or any gradation between them suits best the nature of the substance cut. Thus perfectly even slices can be cut, and it is quite easy to take them in consecutive order even when called off in the midst of the work and compelled to wait half an hour before resuming it. It is a luxury to take off slice after slice and know that there is no danger of losing just the slices you want especially to see. The object is kept wet with glycerine, and just as the razor begins to cut, a drop of glycerine is placed on its edge in which the slice floats without sticking; though care must be taken in the case of very thin and small sections not to lose them in a large drop of glycerine in which they would be found with difficulty. By this method slices $\frac{1}{3000}$ of an inch in thickness, or rather in thinness, can be all worked out nicely, though before it was adopted such thin slices were all torn, so as to be unrecognisable. Whether a blade can be made to cut any thinner than that has not been tried; but it may be remarked that the first razor blade used gave out at $\frac{1}{2400}$ inch thick, and would not take an edge capable of cutting finer than that."—*American Naturalist.*

Dr. Reijner on Synovial Membranes.—We are reluctantly compelled to defer till our next number a paper by Dr. Reijner, of Dorpat, communicating the results of an investigation conducted in Professor Sanderson's laboratory, at University College, on the articular cartilages and synovial membranes. This is in continuation of a previous memoir by Dr. Reijner on the same subject published in the 'Deutsche Zeitschrift für Chirurgie.'

QUARTERLY CHRONICLE OF MICROSCOPICAL SCIENCE.

HISTOLOGY.

II. The Cell.[1] 1. *Action of Quinine on Leucocytes.*—Some years ago, Binz showed that quinine arrests the motions of the white blood-corpuscles, and this effect is now explained by the diminution in the oxidizing power of the red corpuscles which the drug produces. The white corpuscles are only active when they are supplied with oxygen, and their movements are arrested by want of it. On this account they can only creep through the walls of the blood-vessels when oxygen is supplied to them by the red ones as they pass by. When no red corpuscles are present, Binz has found that the white ones cease to wander altogether; and this observation has also been made by Heller and Zahn (Binz, 'Archiv für Experiment Pathologie,' vol. i; 'London Medical Record,' 1873, p. 308).

2. *Contractility of cells.*—Hosch ('Pfluger's Archiv,' 1873, vol. vii, p. 515-521) has observed the contractility of cartilage-cells under the influence of the induced current, as described by Heidenhain and Rollett, in the hyaline cartilage of the frog and newt. Similar phenomena are seen in the corneal corpuscles. Both, he thinks, may be explained by the thermic action of the current, since the same appearances are seen under the influence of heat or merely after death. This explanation applies with less certainty to the newt than to the frog.

3. Dr. Hollis ('Journal of Anat. and Phys.,' November, 1873, p. 120) continues his researches on "Tissue metabolism," or the artificial induction of structural changes in living organisms.

[1] The articles in this division are arranged under the following heads:—I. Text-books and Technical Methods. II. The Cell in General. III. Blood. IV. Epithelium. V. Connective Tissues. VI. Muscle. VII. Nervous System. VIII. Organs of Sense. IX. Vascular System. X. Digestive Organs and Glands. XI. Skin and Hair. XII. Urinary and Sexual Organs.

IV. *Origin of Epithelium.*—The question whether epithelium alone can generate or regenerate epithelium, or whether it may not sometimes be formed from connective tissue elements, lies at the foundation of very important problems of pathology, and even of surgery. We take from the 'Medical Record' (p. 466, 1873) the following summary of the evidence furnished by the modern practice of "skin-grafting:"

"Considerable difference of opinion still exists regarding the histology of this subject. Page, in the 'British Medical Journal,' December, 1870, thought that he had established, by microscopic investigation, that the epithelium of the skin-graft comported itself in the same manner as ordinary cicatricial epithelium; and Jacenko (of Kiew) stated that he found a multiple nucleus in the interior of the cells of the Malpighian layer of the skin-graft. But most observers deny the theory of proliferation. M. Poncet and M. Colrat have both given papers founded on microscopic study, which appear separately in the 'Lyon Médical,' and these observers arrive at conclusions nearly similar to those expressed by M. Reverdin in his essay which appeared in the 'Archives Générales de Médecine' (March, May, and June, 1872). M. Reverdin, on examining the graft forty-eight hours after it had been transplanted, saw that granulations were separated from the graft, and plunged down between the body of the graft and the embryonic tissue of the ulcer, with which the granulations ultimately coalesced to form a single tissue. To these prolongations he gave the name of '*bourgeons d'enchassement*,' or stilt granulations.' He next describes the formation of the cicatrix round the graft. The cells, springing from the graft, have apparently only one nucleus, and he never saw any appearance of it dividing, so that there is nothing to indicate a proliferation of the elements, and in this MM. Poncet and Colrat agree with him. And M. Reverdin further states, seeing that there is nothing to indicate formation of cells from a blastema, that the only hypothesis at which he can arrive is, that the transplanted epidermis determines, by its presence, the transformation of the embryonic cells of the granulations into epidermic cells; that is to say, that the epidermis of the graft will only form a mould or model to the embryonic cells. In practising zoografting, however varied the animals were from which he obtained the grafts, they always produced the same kind of cicatrix, namely, the ordinary cicatricial tissue found in man.

"Opposed to this view, we have the theory which ascribes the principal *rôle* in the production of the cicatrix to the con-

nective tissue; and this is advocated by M. Ollier, who cites, in support of his views, the success obtained by him in producing cicatrisation by means of a graft of periosteum. He might also have added the clinical observation of Howard, with his muscle grafts, as at least opposing the theory of Reverdin.

"Probably the matter would be much more easily solved did we know the mode of growth of the ordinary epithelium. We might then be able to ascertain the difference between the formation of ordinary and cicatricial epithelium; and we would also be better able to ascribe the correct theory to the production of the cicatrix from the grafts. Dr. Otto Weber, long ago, stated that he had seen new cells emanate from connective tissue corpuscles of granulating surfaces. Again, many believe that the epidermic and epithelial cells are derived from the primitive embryonic cells, and that each must be derived from its parent by division of its nucleus; and several observers state that they have seen cells actually undergoing a process of subdivision. The view of Reverdin has been accepted by many; but we think that there is some other cause, some other influence or agency at work in producing the cicatrix from the islets instead of the mere presence of a 'mould.' It finds no homotype in the animal body."

V. The Connective Tissues.—1. *Parenchymatous canals.*—Arnold ('Centralblatt,' 1874, No. 1, p. 1) describes a system of fine parenchymatous canals in the tongue and web of the foot of the frog, the relation of which to the saftcanälchen of Recklinghausen and to the connective tissue corpuscles he proposes further to discuss.

2. *Connective tissue of insects.*—Graber ('Schultze's Archiv,' x, p. 124) describes a sort of fibrilloid connective tissue in the integument of insects, and its importance in suspending the tracheæ.

3. *Development of bone.*—Kölliker's most recent contributions to this subject are thus summarised by Dr. Klein in the 'London Medical Record' (p. 482, 1873):

"1. *The typical absorption of bone tissue.*—The doctrine of the normal absorption of bone tissue by osteoclasts (myeloplaxes), in the Howship's absorption-lacunæ, brought forward by Kölliker,[1] has been lately contradicted by Strelzoff, who found that bone-tissue, once formed, is never absorbed again, but grows interstitially. In the present paper Kölliker brings forward some new facts to meet these objections. At the diaphysal extremities of long bones, the external absorption attacks first the periosteal portion of the bone-cortex.

[1] 'Quart. Journ. Mic. Sci.,' 1873, p. 89.

This being here very thin, the intra-cartilaginous bone therefore is soon involved in the process of absorption. Such absorption-lacunæ remain for many years in the superficial layers of the intra-cartilaginous bone. In transverse sections through the humerus of a human fœtus, especially if they are stained with hæmatoxylin, this is quite clearly to be seen. Such sections, if they are made through the upper extremity of the diaphysis, show laterally a distinct periosteal cortex, and on its external surface an apposition of bone-substance. At the median side, however, this periosteal cortex is absent altogether, and the periosteum is in immediate contact with intra-cartilaginous bone, in which the residua of the trabeculæ of the cartilaginous matrix are brought out remarkably well by hæmatoxylin—a fact first pointed out by Strelzoff himself. At these points the surface of the intracartilaginous bone contains very numerous Howship's lacunæ, and in them as usual osteoclasts. Transverse sections through the tibia below the condyles show exactly the same. Substantially the same was found in the tibia of a male aged fifteen years.

"2. *Formation of the first vessels in bone, developed from cartilage; origin of the osteoblasts and osteoclasts.*—In this paragraph Kölliker confirms the asertion of Lovén, Sharpey, and especially of Gegenbaur, that the marrow of bones which are preformed as cartilage, originates, in all its constituent elements, from the perichondrium or the periosteum respectively. The circumstances that led Kölliker to this conclusion are these:

"(*a*) In the cartilage of the epiphyses and in the short bones the well-known processes of the perichondrium, which project into the cartilage, and which contain, besides blood-vessels, a fibrillar matrix with spherical and spindle-shaped cells, do not develop from the cartilage (Virchow), but from the perichondrium. The cartilage itself does not become dissolved, as supposed, by the progressive growth of those processes. but is simply pushed aside.

"(*b*) In the diaphyses of the phalanges of the embryo of calf, sheep, pig, and man it can be shown that after the appearance of the first thin periosteal crust of true bone substance and the first calcification of the inner cartilage, processes grow from the osteogenetic layer of the periosteum, which spread out gradually towards all sides, and penetrate into the cavities of the cartilage-capsules. The tissue of which these processes consist is similar to that of the perichondral processes, previously mentioned, except that it is more loose, and that it contains more spherical elements. From these latter the osteoblasts and osteoclasts (myeloplaxes) take their origin.

By the growth of those processes the calcified parts of the cartilage-matrix are gradually absorbed, in which proceedings the osteoclasts play an important part.

"The cartilage-cells themselves do not become transformed into cells of the marrow.

"(*c*) Exactly the same takes place at the ossification-margin of the diaphysis, for here the elongated vascular processes, which gradually penetrate from the diaphysal extremity into the cartilaginous epiphysis, are also offsprings of the periosteal processes. Those vascular processes are always and everywhere sharply defined from the cartilage. Osteoclasts are generally not to be met with at the terminal points of the vascular processes, but they occur in great numbers near the ossification-margin; so that they play certainly a part in the absorption of calcified cartilage-matrix, but not in the dehiscence of the cartilage-cavities.

"3. *Growth of bones in length.*—By the well-known method of feeding very young animals with madder, Kölliker arrived in agreement with Ollier and Humphry to the following conclusions as regards the growth of bones in length.

"(*a*) In long tubular bones with epiphyses on both extremities, that extremity of the diaphysis grows quicker whose epiphysis remains longer separated.

"(*b*) Short tubular bones, with only one epiphysis, grow quickest at the diaphysis touching that epiphysis (calcaneus, metatarsi, metacarpi, phalanges).

"(*c*) All free edges and apophyses of any bone show a very marked growth (crista ossia ilii tuber ischii, processus spinosi et transversi, processus xyphoideus sterni, processus styloideus ulnæ).

"(*d*) The same holds good with certain extremities of long bones, which are provided with a considerable layer of cartilage—*e. g.* the ribs.

"(*e*) Short bones, with and without epiphyses, grow pretty equally on all cartilaginous surfaces, which are in contact with other bones (vertebral diaphyses, tarsus, carpus, sternum).

"(*f*) All epiphyses which touch an articulation grow most at the extremity touching the articulation.

"(*g*) Those parts of bones that are covered with cartilage and are not in contact with other bones show a considerable growth. (The edges of the vertebral epiphyses, the lateral parts of all epiphyses.)

"(*h*) The thickness of the cartilage, whose cells are in the act of proliferation, stands generally in relation to the energy

of the growth of the bone in length. There are, however, certain exceptions (vertebral apophyses).

"In the last paragraph of this paper Kölliker produces a new scheme for explaining the growth of long bones. For this, however, we must refer the reader to the paper itself."

Kölliker's important researches, which we have already referred to, are now published in a complete form, with eight plates and many additions ('Die Normale Resorption des Knochengewebes,' Leipzig, 1873, 4to, pp. 86).

4. *Histogenesis of bone.*—Strelzoff ('Eberth's Untersuchungen,' Zurich, 1873, pp. 64, four plates) has published some elaborate researches on the histogenesis of bone, beautifully illustrated, contradicting in some points those of Kölliker.

VI. Muscle.—1. *Structure of voluntary muscle.*—Krause ('Pflüger's Archiv,' 1873, vol. vii, pp. 508—514) discusses the contraction of muscle fibres and the apparent reversal of the characters of the singly-refracting and doubly-refracting substance, as to darkness and lightness ('Umkehrung' of Engelmann) of which he gives a different interpretation from any arrived at by other observers.

Wagener ('Schultze's Archiv,' vol. ix, p. 712) concludes that in striated muscle the fibrilla is the ultimate element of the fibre; that all the forms of transverse discs take their origin only out of the subdivision of the contractile substance in different parts of the fibrilla; and that the intermediate discs are not definite structures.

The observations of Engelmann and Schäfer are thus summarised by Klein ('London Medical Record,' 1873, pp. 647 and 665) with those of other observers already noticed in this journal:

"T. W. Engelmann describes his microscopical observations on the striped muscular tissue in 'Pflüger's Archiv,' vol. vii, part 1. He studied the striped muscular fibres of arthropoda. They were observed in a moist chamber without the addition of any reagent, for reagents produced very marked changes. The fibres were in a perfectly fresh and living condition, showing still very lively contractions.

"Each muscular fibre is divided into a number of divisions of equal sizes by transverse dark membranes—intermediate discs, which are closely united with the sarcolemma. Each division contains in the centre a bright, slightly refractive transverse median stripe—median disc of Hensen, on each side of which lies a dim, highly refractive band—the transverse disc; then comes on each side a bright, slightly refractive band—isotropous substance; then a dark, highly refractive stripe—the lateral disc; and finally, again, a thin,

bright, slightly refractive band—isotropous substance; so that each division contains, between the two intermediate discs, one median disc, two transverse discs, then two isotropous bands, two lateral discs, and finally again two isotropous bands.

"*a.* The intermediate disc, or the membrane of Krause, is distinctly to be recognised as a separate structure in the perfectly fresh fibre in the state of rest, when examined without a reagent, and if the height of a muscular division exceeds 0·008th part of a millimètre. In those cases where the lateral disc is very dark, and is in close contact with the intermediate disc, this latter may easily escape observation; it can, however, be brought into view by slightly stretching the muscular fibre. The intermediate disc appears under the microscope as a single dark line, being a homogeneous, highly refractive membrane; it is very elastic, and, when observed in polarised light, in preparations that have been hardened in alcohol or osmic acid, and mounted in dammar, distinctly anisotropous.

"*b.* The isotropous thin band being at the side of the intermediate disc is in fresh fibres only recognisable when the height of a muscular division amounts to 0·008th of a millimètre and more. Otherwise the lateral disc seems to be in contact with the intermediate disc. In this latter case the isotropous band can be brought into view by adding one per cent. of acetic acid, which causes the isotropous band to swell on and be perceptible.

"*c.* The lateral disc is in the fresh fibre always darker than the isotropous band; it is seldom homogeneous, commonly granular. The granules are generally of equal size, and isodiametric in such a way that, where the muscular contents are divided into fibrils, each granule represents a part of a fibril. The lateral disc is not very distinctly anisotropous; it is also not so elastic and not so closely connected with the sarcolemma as the intermediate disc.

"*d.* The isotropous band between the last-mentioned stripe and the anisotropous transverse disc is always easily to be recognised in the living fibre. Its thickness stands in a reverse proportion to that of the lateral disc. A two per cent. saline solution, water, or very diluted spirit, causes at once this isotropous band to turn dark. When heated up to 50° Cent. (122° Fahr.) it becomes opaque and more firm, and finally it shrinks. It is not a fluid substance, but consists of a number of soft granules of equal size, which are so much swollen that they touch each other completely; the number

of these particles corresponds to the number of fibrils into which the muscular contents split up occasionally.

"*e.* In the fresh living muscular fibre the dim broad transverse disc appears to be divided into two by a median bright homogeneous transverse band. In some cases, however, the latter is not to be made out as a separate structure. Between crossed Nicol's prisms, both the transverse discs and the median disc are seen to be anisotropous. If fresh living muscular fibres be treated with a 5 per cent. saline solution, the transverse discs become swollen and pale, whereas the median disc becomes darker and narrower. Diluted acids and alcohol of 25 to 60 per cent. have a similar action. Heating brings out the median disc and the transverse discs also, as different structures.

"When a muscular fibre dies spontaneously, or is subjected to the influence of water, diluted chromic acid, alcohol, corrosive sublimate, &c., the anisotropous substance appears to be composed of highly refractive anisotropous rod-like bodies —sarcous elements, muscle-rods—and of a less refractive isotropous amorphous intermediate substance. Engelmann distinctly denies that these elements are distinguishable in the muscular fibre while in a living condition; for those parts, in which these elements have made their appearance are without exception non-irritable.

"In some cases the anisotropous discs are the only parts of the muscular divisions which have split into rods, the other parts not showing any sign of a longitudinal differentiation; *e. g.* in muscular fibres of insects which have died spontaneously or which have been treated with water, very diluted saline solution, or diluted alcohol. In most cases, however, especially in locustida amongst insects, and in vertebrate animals in general, the disintegration takes place through all the discs of the individual divisions; in this way the so-called primitive fibrils make their appearance. On observing the optical longitudinal section of a fresh muscular fibre for some time the discs of the divisions, at first absolutely homogeneous, show immeasurably fine pale isotropous longitudinal lines; they are in most regular distances from each other, not more than 0·001 of a millimètre. These lines gradually become brighter, and at the same time broader—their thickness exceeding the 0·0005th part of a millimètre—at the expense of those parts that lie between them, without the muscular fibre, as a whole, altering in diameter. Consequently it may be said that the appearance of the longitudinal bright line is caused, not by the swelling of a pre-existent intermediate substance, but by the shrinking, *i. e.* coagulation, of elements,

which have been previously in close contact with each other; so that all the discs of the muscular division must be regarded as consisting in the living state of prismatic elements, which are so swollen that they touch each other completely, and which possess different chemical and physical properties in the different discs, but the same properties in the same disc. An intermediate fluid substance is not pre-existent, but is pressed out by those elements when they coagulate. In a second paper (ibid., vol. vii, part 2 and 3) Engelmann treats of the changes of the individual discs of the muscular division during contraction of the muscular fibres. For studying these Engelmann uses, like Flögel, osmic acid. The living muscular fibre is dipped into a solution containing 0·5 to 2 per cent. of this reagent for a few seconds; it is then transferred into a half per cent. saline solution, which is afterwards replaced by alcohol in a slightly rising concentration (50 to 90 per cent.), and is finally placed in turpentine. The conclusions which Engelmann draws from his observations are briefly these:

"*a.* The shortening force has its seat exclusively in the anisotropous layer; this latter thickens itself much more than the isotropous.

"*b.* The isotropous substance *decreases*, the anisotropous *increases* in volume during contraction; it must be therefore assumed that fluid which is expressed by the isotropous is imbibed by the anisotropous substance, viz. the latter swells, the former shrinks, during contraction.

"*c.* The isotropous substance becomes darker, more opaque, the anisotropous brighter, more transparent, during contraction; the median disc, however, does not become brighter. From this it may be deduced that—

"*d.* The isotropous substance becomes firmer, the anisotropous softer, during contraction.

"E. A. Schäfer ('Proceedings of the Royal Society,' vol. xxi) studied the structure of striped muscle on the muscular fibres of the limbs of the common large water-beetle, mounted without any reagent, and under high magnifying powers. According to Schäfer, every muscular fibre consists of a homogeneous *anisotropous* ground-substance, in which are imbedded dim cylindrical rods; these are *isotropous*, and arranged in regular series. In the absolute state of rest the muscular fibre presents, therefore, only the appearance of a longitudinal fibrillation. In the normal state of slight tension the cylindrical rods change into rods with a swelling at each extremity; we have then muscle-rods consisting of a shaft and two little knobs or heads. When this change has

taken place the muscular fibre presents the appearance of a transverse striation, viz. dim bands alternating with bright ones. The former correspond to the dim shafts of the rods, whereas the latter are due to an optical effect, produced by the presence of the globular heads of the rods, which have a different refraction-index from that of the ground-substance. In this case the muscle-rods are so arranged that the heads of two successive series meet in the middle of the bright band; when the muscular fibre is somewhat extended the bright band appears to be double, for then the heads of two successive series of rods have become separated, and each series of heads possesses its own halo. During contraction the heads of the rods become enlarged at the expense of the shafts, and at the same time they approach each other in the transverse as well as in the longitudinal direction to such an extent that they form one dark transverse band with bright borders. As the contraction proceeds, and the dark bands approach each other, the bright borders encroach upon the dim stripe, which finally disappears, its place being taken up by a single transverse bright band. The contracted muscular fibre shows, therefore, alternate dark and bright bands, the latter representing merely the ground-substance, which has become accumulated between the shafts of the muscle-rods. In polarized light these bright bands are seen to be anisotropous, whereas the dark bands are isotropous. From this it is evident that the ground-substance is anisotropous, the muscle-rods isotropous, although in the state of rest the whole fibre appears to be anisotropous; this, however, may be easily explained by bearing in mind that the muscle-rods are surrounded by the anisotropous ground-substance and are therefore illuminated by light that has previously traversed this.

"Schäfer is inclined to assume that the ground-substance is comparable to a protoplasmic matrix, which is the true contractile part, whereas the rods are elastic structures, which serve merely to restore the muscular fibre to its original length after the contraction has ceased."

2. *Termination of nerves in voluntary muscle.*—Arndt ('Schultze's Archiv,' ix, 481) publishes a long and elaborate memoir on this subject, illustrated with three plates, which our space does not permit us fully to notice.

3. Petrowsky ('Centralblatt,' No. 49, 1873, p. 769) has studied the growth of muscular fibres in the frog.

VII. Nervous System.—1. *Nervous structures in general.*—Axel Key and Retzius ('Schultze's Archiv,' 1873, ix, pp. 308—368, 3 plates) publish a long memoir, translated from a Norwegian journal, on the anatomy of the nervous system,

partly microscopic, partly histological, describing the nerve-centres with their membranes, the structure of nerve-trunks, the Pacinian corpuscles, &c.

2. *Regeneration of nerve.*—Benecke ('Virchow's Archiv,' 1873, vol. lvii, pp. 496—511) has studied the histological process in the regeneration of nerves after section.

3. *Ganglion-cells of the sympathetic.*—Arndt ('Schultze's Archiv,' x, p. 208) has investigated the structure of the ganglionic cells of the sympathetic in fish, birds, mammalia, and in the human subject. He worked partly on preparations macerated in neutral chromate of ammonia and teased out, partly on hardened specimens, using chromic acid and chloride of gold. He thus summarises his results:—1. All ganglionic cells of the sympathetic, provided with several processes, that is, *bipolar* and *multipolar* cells, correspond to whole groups of cells, and are derivatives of such groups. 2. All *unipolar* ganglion-cells, on the other hand, correspond to and are derived from simple cells. 3. Of the so-called apolar ganglion-cells, the larger represent abnormal developmental forms of the original embryonic cells; the smaller are, in fact, themselves embryonic cells.

4. *Cortex of the brain.*—Golgi ('Centralblatt,' No. 51, 1873, p. 806) publishes a preliminary communication on the grey substance of the brain, especially with reference to the large pyramidal ganglion-cells of the cerebrum, the 'basal process' of which he finds to branch and finally to enter into connection with the connective-tissue-cells of the cerebral cortex. Similar relations he finds to exist in the cerebellum.

5. *Nervous system of Nematoda.*—Bütschli, "Contributions to the Knowledge of the Nervous System of the Nematoda" (2 plates), 'Schultze's Archiv,' x, p. 74.

6. *Electrical organs.*—Boll ('Schultze's Archiv,' x, p. 101) has studied the electrical plates of the Torpedo with high powers, and the same organs in Malopterurus (ibid., p. 242).

7. *Aniline blue as a staining material for ganglion-cells.*—Zuppinger ('Schultze's Archiv,' x, p. 255) recommends for the demonstration of the axis-cylinder process of the ganglion-cells in the spinal cord the use of soluble aniline blue, according to the following method:—Sections of brain or cord hardened in bichromate, and washed with acidulated water, are brought into a slightly acidified solution of commercial aniline blue and kept in the dark till they are stained of a tolerably deep colour. The sections must not overlap or cover one another. They cannot be dehydrated by alcohol, since this extracts the colour, but a little absolute alcohol may just be poured over them to remove some of the adhering water, and

then white anhydrous creosote added, which soon makes them translucent without destroying the colour, and they can then be transferred to Canada balsam or dammar. They must not be left more than two hours in creosote, and must still be shielded from the light, which precaution is to be observed even when the preparations are complete and transferred to the cabinet.

VIII. Organs of Sense.—1. *Olfactory mucous membrane.*—Martin ('Journal of Anatomy and Physiology,' November, 1873, p. 39) has worked at the structure of the olfactory mucous membrane, especially with a view to examine the distinction drawn by Max Schultze between the two classes of cells, *epithelial* and *olfactory*, met with in this region, a distinction which Exner denies. In the olfactory epithelium of the newt these two kinds of cells are very distinct, and no intermediate form is seen. They are clearly demonstrable on teasing out preparations hardened in spirit or Müller's fluid. The epithelial cells possess a large oval granular nucleus, surrounded by a homogeneous structureless layer, from which proceed one or more 'central processes;' a 'peripheral process' proceeds from the other end of the cell. In the olfactory cells the nucleus is round, hardly granular, and has a single central process. In the frog the two kinds of cells are less distinct, partly because the nuclei of both are oval. In the olfactory epithelium of the dog the two forms are quite distinct, though differing somewhat from the corresponding cells in the newt.

The conclusion is that the two forms of cell met with in the olfactory region are anatomically quite distinct, as described by Max Schultze, and do not shade off into one another. The contrary opinion arrived at by Exner is due in great part to his having chiefly worked at the frog, where the olfactory and epithelial cells do approximate to one another in several points. It is doubtful whether the cells possess any such difference of function as is implied by these terms.

IX. Vascular System.—1. Morano ('Centralblatt,' No. 1, 1874, p. 3) describes the lymphatic sheaths of the capillary blood-vessels in the choroid coat of the eye.

2. Klein ('Proc. Royal Society,' No. 149, 1874) publishes his "Contributions to the Normal and Pathological Anatomy of the Lymphatic System of the Lungs," of which we must defer a notice.

X. Digestive Organs and Glands.—1. *Teeth.*—Legros and Magitot have studied the development of teeth in mammalia, and describe, in their first memoir, the origin and formation of the dental follicle. (Robin's 'Journal de l'Anatomie,

September and October, 1873; also separately, pp. 56, with six plates).

2. *Thyroid*—Boéchat ('Recherches sur la Structure normale du Corps Thyroide,' Paris, 1873, 8vo, pp. 44, one plate) describes the normal structure of the thyroid.

XI. Skin and Hair.—1. *Tactile corpuscles.*—Thin ('Journal of Anatomy and Physiology,' November, 1873, p. 30) describes the structure of the tactile corpuscles. After referring to the views of several observers, he gives an account of his own observations, made on recently amputated skin, hardened chiefly in osmic acid. A vertical section through the meridian of a corpuscle shows either a simple homogeneous, more or less rounded body, enclosed in a capsule, or two or more such simple capsulated bodies arranged in a row parallel to the vertical axis of the papilla, and enclosed in a common oblong capsule. The former he designates single, the latter compound corpuscles. Each single corpuscle, and each member of a common corpuscle, is penetrated by one, and never by more than one, medullated nerve-fibre. A nerve never leaves a corpuscle after having entered it, but when it has penetrated to a certain depth bends round and describes part of a circle. In this terminal course the nerve retains its medulla, and between the medulla and corpuscle substance a space is seen which corresponds to the position of the sheath of Schwann. Thin has never seen the nerve-fibre divide, either internal or external to the capsule, and does not hesitate to deny the alleged division. The conclusion is that each single corpuscle, and each member of a compound corpuscle, represents the termination of a single medullated nerve-fibre.

The so-called transverse elements (*querelemente* of German authors) are the nuclei of oblong cells which anastomose with one another, by means of prolongations of elastic-tissue-fibres. The capsule of the corpuscle is formed by a circular layer of elastic tissue made up of the anastomosing continuations of cells. The network of elastic tissue and the cells do not communicate with the medullated nerve-fibres. The division of the papillæ of the skin into vascular and nervous is not borne out by these investigations, since in the majority of the so-called nerve-papillæ vascular loops are found.

2. *Lymphatics of the skin.*—Neumann ('Zur Kenntniss der Lymphgefässe der Haut des Menschen und der Säugethiere.' Mit 8 chromolithographirten Tafeln. Wien, W. Braumüller, 1873. 'Medical Record,' 1873, p. 664) has arrived at results which may be summed up as follows:

(1). The lymphatics of the skin present an enclosed tubular

system, with independent walls, whose interior is lined with flat epithelium. These walls are nowhere interrupted by openings. There exists, therefore, no communication with the so-called juice-canals, or with other interspaces of the skin. Neither can spaces be seen anywhere between the epithelium, not even in examples of disease where there exists an enlargement of these vessels.

(2). The relation of the blood- and lymph-vessels is only constant to the extent that the former are always found much nearer the surface than the latter. The branches of the lymphatics, together with their meshes, are found spreading themselves in the deeper tissue in all directions. Nowhere, however, within a lymph-tubule could a second vessel be detected; so that there can be no ground for considering the question of invagination.

(3). The lymphatics form two close and separate networks in the corium, the deeper being the more extensive of the two. Their walls are markedly capable of extension. The more superficial vessels are in general thinner; the deeper ones are thicker, and, like the first, are, to all appearances, without valves. Only among the subcutaneous vessels is it possible to demonstrate the valves plainly.

The larger lymphatics possess a number of branches with blind endings, which are of variable calibre. The lymph-vessels make their way into the papillæ of the skin, partly in the shape of single tubules, and also in the form of loops.

(4). The appendages of the skin, as the hairs, hair-follicles, and sweat-glands, possess their own lymphatic capillaries situated about their periphery, but they do not enter into the follicles. The aggregations of fat are also surrounded by lymphatics. The vessels were found to be greatly developed in the subcutaneous tissue.

(5). The number of lymph-vessels of the skin was found to vary according to locality. They occur in greatest numbers about the scrotum, labia majora, palms of the hands, and soles of the feet. In pathologically altered skin an enlargement of the vessels was at times demonstrable.

In ulcerative processes the lymphatics are, in part, destroyed, though they may be regenerated. They occur only sparsely in cicatricial tissue. No vegetations were observed upon the walls of the vessels.

XII. Urinary and Sexual Apparatus.—1. *Kidney epithelium.*—Heidenhain ('Schultze's Archiv,' vol. x, p. 1) describes remarkable and hitherto unobserved peculiarities of structure in the epithelium of the kidney. In the convoluted tubes the epithelia are not simple cells, but very complicated

organized structures. A considerable portion of the protoplasm of the cell has undergone important modifications, being converted into a large number of very delicate cylindrical bodies, which Heidenhain calls rods (stäbchen). Attached by their outer ends to the tunica propria, they traverse the epithelial layer in a radial direction, being imbedded in a very small quantity of amorphous interstitial substance. The nuclei, which lie at regular intervals, surrounded by a more or less considerable quantity of undifferentiated protoplasm, are enveloped by these rods, and what have been till now described as dark granules in the body of the cells are for the most part nothing but cross sections of the rods. This conclusion is arrived at from investigations chiefly on the dog's kidney, but the author recommends (for the study of the organ in a perfectly fresh state) those of the rat and the hedgehog. The perfectly fresh specimens, examined either in longitudinal or transverse section (with objective 8 or 9 of Hartnack), show a striated appearance, indicating the presence of the rods. The latter are seen more clearly in sections from specimens hardened in neutral chromate of ammonia (5 per cent.) and alcohol successively. Another method of hardening is to inject a saturated solution of potassium chloride into the renal artery, and then harden in spirit. Isolation of the elements is best effected by maceration in caustic soda (33 per cent.), or in the 5 per cent. solution of neutral chromate of ammonia. The rods thus isolated are found to be cylindrical structures, somewhat variable in size, some being as long as the whole thickness of the epithelial layer, others shorter, and varying also in breadth. The nuclei of the epithelium are also isolated by the same means, and found to be surrounded by a protoplasmic mass, which in some animals is separated from the rods, in others continuous with them. There is also a small quantity of residual cement substance between the rods. The nuclei and their surrounding cell body never touch the wall of the tube, which only shows the attachment of the rods. In the looped tubes of Henle substantially the same relations are seen, but no rods were discernible in the epithelium from the straight tubes of the pyramids or the large collective tubes of the papillæ.

The comparative structure of the kidneys of birds and snakes is illustrated by observations which we must pass over.

Experiments on the function of the kidneys were made by Chronsczewski's method of injecting indigo sulphate of soda into the circulation (pure and specially prepared solution is necessary, that usually obtained being impure). Heidenhain

concludes that the kidney is the specific excreting organ for this substance, as for urea, but that in this the Malpighian capsules take no part. The secretion is effected by the epithelium of the convoluted tubes, which have a certain power of reducing the indigo solution. The single tubes may act quite independently of one another. The straight tubes serve merely for conveying away the secretion when formed.

The conclusions drawn as to the function of the kidneys are that not all the constituents of the urine are secreted in the Malpighian capsules; and Ludwig's view, that the urine as a whole is a filtrate from the blood in the capsules, is untenable. If the results attained with indigo may be extended to the normal urinary products, Bowman's view, that the Malpighian corpuscles exude only water, with perhaps salts of low atomic weight, must be adopted.

Rods similar to those seen in the kidney are met with in the ducts of the parotid and submaxillary glands, and those of certain glands of the nose, but not in the submaxillary. These glands, however, show no corresponding difference of function.

2. *Spermatozoa.*—Merkel publishes a preliminary notice on the development of spermatozoa ('Centralblatt,' No. 5, 1874, p. 65).

PROCEEDINGS OF SOCIETIES.

Royal Microscopical Society.

December 3rd, 1873.

Charles Brooke, Esq., F.R.S., President, in the chair.

A paper was read by the Rev. W. H. Dallinger and Dr. J. Drysdale on "Further Researches into the Life-History of the Monads," in continuation of that read at the November meeting.

The authors subjected, as before, certain forms of monads obtained in a maceration-fluid to continuous observation with high powers, especially with a view to discover the method of increase or multiplication. Fission has not proved in any case persistently inquired into by them to be the essential method of multiplication; though, since it is an accurate statement of facts so far as they go, it is not surprising that it should be generally accepted as the entire method. Nor has fission itself, they think, in these minute forms, been described with sufficient care. It is not a mere division of undifferentated sarcode into two parts. Before separation takes place there is always a germination of the anatomical elements, which make the new monad complete; while in many instances the fission is completed by a suddenly induced amœboid condition. The original form has two flagella, one permanently hooked, the other flowing. In fission similar structures are formed for each new individual thus produced. Multiplication by this method may continue without apparent interruption for many days; but eventually two, four, or even six of the monads may unite together, take a flaccid sac-like form, becoming quickly distended, and dividing internally into segments, which go on subdividing till the sac is filled with beautiful oval bodies which eventually escape, and are found to possess a single flagellum; these rapidly grow, acquiring in a manner not clearly made out the second (hooked) flagellum; and when thus mature recommence multiplication by fission. This is the comparatively simple life-history of the form. The paper is published at length, with illustrations, in the journal of the Society.

Mr. Charles Stewart called the attention of the meeting to a section of the leaf of an india-rubber plant, which showed con-

cretions or "cystoliths" existing in some of the cells. It was a question whether these concretions were really composed of crystals of carbonate of lime. He thought that they might be regarded as cellulose or some gum-like material deposited upon a cellulose stem.

A *scientific evening* was held in the Hall of King's College on December 10th, when a number of interesting objects were exhibited.

January 7th, 1874.

A paper was read in continuation of the Rev. W. H. Dallinger and Dr. Drysdale's "Researches into the Life-History of the Monads." They described the development of a very simple form of monad,—oval with a single flagellum, and not exceeding $\frac{1}{4000}$th of an inch in diameter. One mode of increase was by multiple fission. An ordinary egg-shaped monad passes through a series of mutations of form till it settles as a minute sphere. A white cruciform mark suddenly appears, and is succeeded by others at right angles to the first. A rapid interior action ensues, and at length the whole body of the sarcode is divided into a large number of long bodies packed closely together, which separate as flagellate monads. Conjugation is also observed. There is a much smaller number of larger rounder monads, distinguished by their granular aspect, which seize and absorb the common form. The result is a still condition in the form of a sphere. This eventually opens, and a fluid is poured out, or what appears like it; no sporules can be seen. The result of this, however, is the growth of minute specks, which we can only suppose to come from invisible germs; and from these forms grow like the parents, and the circle is by them re-entered.

A paper was read on "The Origin and Development of the Coloured Blood-Corpuscles in Man" by Dr. H. D. Schmidt, of New Orleans.

The author had the rare opportunity of examining a human ovum which was not less than three weeks and not more than three months old, immediately after expulsion. It did not exceed $2\frac{1}{2}$ centimetres in diameter, and when opened contained a balloon-shaped vesicle, the umbilical vesicle, and a mass of cells and nuclei, representing the embryo. On cutting into the wall of the vesicle it was found to contain many blood-corpuscles, in various stages of development, moving through smaller or larger canals. Most of the corpuscles resembled fully developed human corpuscles, but some larger ones appeared to be breeding or mother-corpuscles, and contained blood-embryo disks within them. Many of them had on their surface certain regularly formed concave depressions, indicating the place where young corpuscles had been detached. The process of multiplication consisted in the separation from the mother-body, and near its surface, of a small globular portion which represents the embryo blood-corpuscle. This enlarges and makes its way to the surface, where,

on being detached, it leaves behind a concave depression. This differs from the prevailing belief that multiplication takes place by division of coloured nucleated corpuscles. The process represents a transition from endogenous formation to budding or gemmation.

Accumulations of blood-corpuscles were seen, beside in the canals, in certain spaces limited by two layers of hexagonal cells, forming a system of *primary glandular follicles.* The nuclei of these hexagonal cells become the breeding- or mother-corpuscles before mentioned. The author concludes that the primary birthplace of the coloured blood-corpuscles in the human embryo is to be sought in the above-described gland-like follicles of the umbilical vesicle. This view differs, of course, entirely, as he admits, from the older observations, as from the later of Klein and those of Balfour published in this Journal last year. Further observations are given on the later development of the blood and on the structure of the corpuscles, for which we must refer to the original paper and plates published in the Society's journal.

Another paper by the Rev. W. H. Dallinger, on "A Method of Preparing Lecture Illustrations of Microscopic Objects" was also read.

Medical Microscopical Society.

At the ninth ordinary meeting of the Medical Microscopical Society, held at the Royal Westminster Ophthalmic Hospital, on Friday, November 21st, Jabez Hogg, Esq., President, in the chair; the minutes of the previous meeting were read and confirmed.

Dr. Bruce described at some length the various methods of studying inflammation. He considered that observing inflammation in the frogs's foot was useless for two reasons:—1. The epithelial surface soon becomes dim with the action of reagents, so as to obscure the vessels. 2. The vessels are not altogether suitable, and, besides, there is sometimes difficulty in stretching the web between the toes without interfering materially with the circulation.

He therefore preferred the mesentery—and recommended Hartnack's microscope—beginning the examination with a low power and afterwards using Hartnack's No. 7 objective (equal to an English quarter in magnifying power). The frog plate should consist of a piece of glass with a cork (having a circular hole in the middle and covered with a small cover of glass) cemented with sealing wax to the one end of it. The mesentery is then pinned out upon the cork over the glass. The frog should be injected with one minim of a $\frac{1}{6}$ per cent. solution of curare subcutaneously, because this paralyses all the muscles except the heart; then make an incision along the right side of the body about an inch in length in a line with the leg and

arm, avoiding all blood-vessels, so as to prevent blood corpuscles getting on to the mesentery, then draw out the intestine, and having placed the mesentery on the cork plate moisten its surface with salt solution. It is best to expose the mesentery for three hours before the observation be made, and a large vessel is best for examination. The chief difficulties which may be experienced are (*a*) imperfect curarization, (*b*) adhesions, or (*c*) tearing the mesentery.

The mesenteries of warm-blooded animals had been used by Stricker on his large warm stage, but Dr. Bruce had no experience with them himself, and their examination was attended with a good deal of difficulty.

The tongue of the frog is useful for studying inflammation. Cohnheim first used it, placing the frog on its back and observing the dorsum of the tongue, in which he excited inflammation by snipping the mucous membrane; caustic has also been used for this purpose. Cutting the mucous membrane, however, gives rise to hæmorrhage, therefore Cohnheim prefers making use of the under surface, in which he causes inflammation by passing a ligature round the root of the tongue. At the end of forty-eight hours he undoes this and then white blood-corpuscles are seen to be passing freely through the vessels. Dr. Bruce has found, however, that after ligature the circulation does not always recover. To prevent the ligature injuring the tongue it is best to place a piece of leather between the ligature and the tongue. Dr. Bruce also referred to the tail of the tadpole, the wing of the bat, and the cornea of the rabbit, &c., as structures in which inflammation may be observed; and then concluded by asking an opinion as to the origin of pus, whether the members held with Cohnheim, that all pus comes from the vessels, or from the connective tissue corpuscles, or from both sources.

The President stated his opinion that investigating living tissues would probably be the only means of advance in pathological research. Paget even gave but crude information on inflammation, while Cohnheim has elucidated much in living tissues.

Dr. Payne referred to the difficulty of Cohnheim's experiment on the mesentery. He also thought that Virchow's idea of the origin of pus, though now old-fashioned, was far from being overturned by Cohnheim, and that in inflammation of mucous surfaces we see instances of small cells in larger (mother) ones, though he acknowledged it might be true that the small cells migrated into the larger. In the cornea and omentum proliferation has been seen. One view may be taken of all these structures, viz. that some parts of the body, and especially those of embryonic character show greater tendency to reproduction than others. He had heard Virchow state his conviction that the more perfect endothelium of the peritoneum could not go on producing other elements while the more simple endothelium of the lymphatics might do so. Dr. Payne then stated that at present only a small class of tissues had been studied in a living and inflamed condition, and until all tissues have been examined it

was not fair to speak generally on the subject. The escape of colourless blood-corpuscles was undoubtedly an abundant source of pus whatever other origin it might have.

Dr. Evans asked what effect curare had on the tone of the vessels.

Mr. White asked if Dr. Bruce had tried the effect of chloroform vapour on a curarized frog, because he had noticed a regurgitation or stoppage in the circulation as a result.

Mr. Schäfer preferred the mesentery of the toad to that of the frog because it is longer and has a lymphatic sac in its centre.

Dr. Matthews suggested the use of a spring clip instead of a ligature for the frog's tongue, and said that the use of curare might be obviated by immersing the frog for a short time in warm water.

Dr. Bruce, in reply, stated that he was not aware that curare had any influence upon the process of inflammation. He had not tried chloroform for frogs. He also stated that the same results as Dr. Matthews produced by placing a frog in warm water might more conveniently be brought about by holding the frog in the hand for a few minutes.

Mr. Needham then showed his modification of Dr. Rutherford's microtome, which consisted in its having a movable glass plate on the upper surface, through which the cylinder containing the embedded specimen projected nearly, but not quite, to the level of the cutting surface.

Dr. Matthews showed another modification of the same microtome, and also a diagonal razor with the shoulder ground down flush with the rest of the blade, which he found more handy than the ordinary razor.

Mr. Miller advocated the use of a steel plate for the upper surface of a microtome, the great drawback to its use being the liability to rust. He preferred a thick razor.

Mr. Clippingdale showed a micro-spectroscope, in which two spectra could be compared in one and the same field.

Mr. Kesteven described a method of microscopic drawing in which the neutral tint glass of Dr. Lionel Beale's reflector was removed and an ordinary thin cover glass substituted.

Dr. Bruce then exhibited his specimens illustrative of inflammation.

At the tenth ordinary meeting, held Friday, December 19th, Jabez Hogg, Esq., President, in the chair—

Mr. J. W. Groves read a short paper "On methods of examining circulation and urinary deposits by means of water-tight caps over the higher powers of the microscope, after the fashion of Mr. Stephenson's submersion microscope." By this means he said that

the circulation in a frog's foot could be watched for several consecutive days, because having half an inch or more of water over it the web could not become dry, and moreover there was no necessity for irritating it in any way, whereas it was scarcely possible to avoid irritating it if an immersion lens were made use of, because a single drop of water only being used at a time this was constantly evaporating, and had as constantly to be renewed. In his opinion, for class demonstration this method of showing circulation was superior to every other, not even excepting the immersion-lens system. He had himself used it for this purpose and had found it to answer most admirably.

Mr. Groves then said that if the sediment of a pint or more of urine were emptied into a small flat glass dish with as little of the urine as necessary, by means of the water-tight cap over an object glass, the whole deposit could be examined in the course of a few minutes, whereas if examined drop by drop on a slide, much of the deposit would be lost and hours would be required for the examination of such as was secured.

In the discussion which followed, Dr. Matthews, Dr. Foulerton, Mr. Giles, Mr. Miller, Mr. Hogg, and Mr. White, took part.

Mr. T. C. White described a small and painful tumour which he had found in the cavity of a decayed tooth.

Mr. Hogg read notes and exhibited specimens of a case of Bright's disease.

In the discussion which followed Mr. Hogg's remarks the following gentlemen took part, viz. Dr. Matthews, Dr. Foulerton, Dr. Bruce, Mr. Atkinson, Mr. Needham, Mr. Stowers.

Mr. Hogg exhibited charts of the spectra of chlorophyll.

Mr. White considered that probably at some future time charts of the spectra of chlorophyll might prove of great service in medico-legal inquiries.

The first annual meeting of this society was held January 16th, at 8 p.m. o'clock, at the Royal Westminster Ophthalmic Hospital, Jabez Hogg, Esq., President, in the chair. From the report of the committee it appeared that the society, though only one year old, was in a most flourishing condition. During the year 129 members had joined it and sixteen papers had been read, each of which was followed by a lively discussion, and at no meeting was there any lack of specimens for exhibition.

The following gentlemen were elected officers for the ensuing year:—President, Mr. Jabez Hogg; Vice-presidents, Mr. W. B. Kesteven and Drs. H. Lawson, J. F. Payne, and W. Rutherford; Treasurer, Mr. T. C. White; Hon. Secretaries, Messrs. C. H. Golding Bird and J. W. Groves; Committee, Drs. M. Bruce, E. C. Baber, U. Pritchard, W. S. Greenfield, W. H. Allchin, J. Matthews, and Messrs. H. Power, F. T. Paul, J. Needham, G. M. Giles, S. Coupland, E. A. Schäfer.

The President then delivered his address, after which votes of thanks were accorded to the various officers, and the proceedings terminated.

At the eleventh ordinary meeting of this Society, held on Friday, February 20th, Jabez Hogg, Esq., President in, the chair, the minutes of the previous meeting were read and confirmed. The names of those gentlemen for proposal were read, and three other gentlemen were duly elected members.

In the unavoidable absence of the Secretaries, the Treasurer, Mr. T. C. White, read a communication from Mr. J. W. Groves, "On cataloguing and arranging microscopical specimens," which will be published in the next number of this Journal.

A vote of thanks having been passed; the President said he thought the method proposed would supersede all others in use at the present time.

Mr. Needham endorsed these remarks, and said he had been in the habit of classifying his slides in physiological series, thus—respiratory, digestive, &c., but this system had one great objection which Mr. Groves's obviated, viz.—that one slide might deserve to be placed in several series but could not be, and, consequently there was a great multiplication of specimens, and some difficulty often in finding any particular preparation.

Mr. Giles, Dr. Matthews, Dr. Donkin, and Mr. R. P. Miller also joined in the discussion.

Mr. Sidney Copeland then made some remarks on preparations of "Tuberculosis of the Choroid" in a child æt. 8 years. After describing the normal structures, and stating that he intended to confine himself wholly to the histological characters, he said—That on removing the retina the tubercles were seen as translucent bodies, averaging $\frac{1}{30}''$ in diameter, the centres of which were mostly white and opaque from degenerative causes. The chorio-capillaries could be traced partially over the tubercles. There was a marked deficiency of pigment and a notable increase in the number of the large pale spheroidal bodies. The tubercles were composed of nucleated cells $\frac{1}{4500}''$ to $\frac{1}{3000}''$ in diameter, and with these were seen some larger and variously shaped cells, having more than one nucleus, some of which were possibly derived from the normal pale spheroidal cells, though these were quite as numerous.

The tubercles appeared to arise from the middle layer of the choroid and always around the vessels. In the older tubercles the central portions were made up of semifibrous and caseous material, the peripheral only exhibiting the small cell growth. From this distribution it was evident that the growth was perivascular, and this had probably arisen from a proliferation of the lymphatic endothelia, as in tubercles of the pia mater.

A vote of thanks having been accorded to Mr. Coupland, the President, Messrs. Power, Cowell, Atkinson, Needham, and Miller joined in the discussion.

In reply, Mr. Coupland said he had not examined the retina microscopically, but that the ophthalmoscope showed nothing abnormal. The eyes had been removed two hours after death, placed in Müller's solution for two weeks, thence into a solution of gum acaciæ, from that to methylated spirit which rendered it horny and fit for embedding. The gum was removed from the sections by immersion in water, or by simply placing them direct into the staining fluid.

There was a short discussion on the subject of Finders, and the Meeting then resolved itself into a conversazione, when several interesting preparations were exhibited.

The meetings for the next three months will be Fridays, April 17th, May 15th, June 19th, at the Royal Westminster Ophthalmic Hospital, at 8 p.m. o'clock.

Liverpool Medical Institution.—Microscopical Section.

The fifth Session of the Microscopical Section of the Liverpool Medical Institution was inaugurated with a conversazione on October 9th, 1873, given by the President of the Society—Dr. John Cameron. Besides a very attractive exhibition of paintings and works of art, there were exhibited a number of the most recent physiological instruments, microscopes illustrating various branches of natural science, and a large collection of pharmaceutical preparations.

The second meeting was held on November 14th, 1873, when Dr. Davidson read a paper on "The Histology of Cancer of the Liver." Basing his remarks on the careful examination of several cases of this disease which had recently been under his care, Dr. Davidson commenced by inquiring—"Do the normal tissues give way before the cancer, or do they take part in its formation; and if so, which tissues of the liver are converted into cancer, and what part of the cancer do they individually go to form?" In examining sections made from a liver affected secondarily by cancer, showing nodules interspersed here and there, while the hepatic tissue was also "infiltrated without losing entirely the appearances of normal liver," the author observed the cancer to make its way along the portal canals, and at intervals the lumen of the portal veins was completely occupied by a plug of cancer cells. Passing to the lobules, cancer cells could be detected within the blood-vessels, causing their dilatation, and pressing on the surrounding hepatic substance. Dr. Davidson considers this form of hepatic cancer to be originated either by cancerous emboli being carried into the vessels, or by the epithelium of the

vessels taking on a cancerous growth. The liver cells appear to take no part in the formation of cancer, but are stretched by the growth taking place in the vessels, and ultimately disappear. On examining livers affected with primary cancer, Dr. Davidson observed their connective tissue to be greatly increased both in the portal canals and between the rows of liver cells; while at intervals are seen groups of liver and other cells enclosed by the bands of newly formed connective tissue, so that it is very difficult to say whether in these cases the liver cells do not by degrees pass into cancer cells.

At the same meeting Mr. Newton exhibited a specimen showing "seeds of a foreign fruit, uric acid crystals, very large crystals of the triple phosphates, and mannite," which had been passed per rectum by a patient presenting the symptoms of passing gall-stones. In the discussion which followed several gentlemen mentioned instances of patients passing phosphatic and uric acid crystals, for several days in succession, along with the fæces. The meeting was brought to a close by the members proceeding to examine the specimens placed under about a score of microscopes, and illustrative of the paper and communication for the evening.

The third meeting was held on December 12th, 1873. The paper read on this occasion by Mr. D. J. Hamilton on "The Morbid Anatomy of Epilepsy" was very exhaustive and replete with original research. At the author's request we refrain from further notice of it, as he intends ere long to publish it *in extenso.* Mr. D. J. Hamilton illustrated his paper by numerous sections of the spinal cord from epileptics; and exhibited also a section of an hypertrophied lymphatic gland.

The fourth meeting was held on January 30th, 1874, when Mr. Rushton Parker read a paper on "The Development and Growth of the Mammary Gland, and its Minute Anatomy in Health and Disease." Developed from the outermost layer of the blastoderm, the mammary gland is first recognisable in the fœtus of the third month as a series of single tubes converging to a central point and which afterwards extend beneath the skin by a budding and lengthening of themselves and their offshoots; the nipple being substituted at this date by a depression. At birth the gland consists of a number of tubes radiating from the nipples, lined with columnar epithelium, and ending blindly at the tip of each ray. At puberty in the female these blind tips of the gland ducts grow out into vesicles (termed acini) lined by spherical epithelial cells which under the influence of mutual pressure become polyhedral and slightly angular. The acini next multiply, form clusters like grapes, and are surrounded by an abundance of connective tissue. When the first pregnancy takes place the acini become further multiplied, each mammary lobe enlarges, more blood passes through, and the connective tissue gets succulent. Each acinus acquires an increased epithelial area, new cells forming rapidly and becoming insinuated between

those already existing, much epithelium is shed, each cell undergoing fatty degeneration and lying in a serous medium; in fact, milk is formed. The connective tissue also shows increased developmental activity and is charged with leucocytes that have escaped from the blood-vessels. The blood-vessels surround the secreting passages, but do not penetrate their epithelial layer. The author next described the minute anatomy of the nipple, and the probable arrangement of the lymph-vessels and lymph-lacunæ in the mammary gland. Having alluded to the retrogressive changes which occur after each lactation, and still further after menstruation has ceased, he mentioned the abnormalities which have been met with in the number and position of the breast and nipples. Having described shortly the varieties of ulceration which attack the nipples—simple, syphilitic, eczematous, and very rarely cancerous—Mr. Parker referred to atheroma of the sebaceous glands around the nipple, to acute and chronic abscesses of the mamma at various periods of life, and to that very rare condition—true hypertrophy of the mamma, and then proceeded to examine the microscopical characters of mammary tumours. These he divided into two classes: (*a*) those arising in the connective tissue of the gland; and (*b*) those which have their origin in its secreting substance. Although mammary tumours arise in one of the above two ways, in nearly all secreting substance is found mixed up with the tumour, more or less altered, but present nevertheless throughout. Lipoma or fatty tumour, enchondroma or cartilaginous tumour, and fibroid or fibrous tumours, were mentioned as rare affections, the usual tumour found in the mammary connective tissue being one of the varieties of sarcoma. The seat of sarcoma here is immediately beneath the glandular epithelium, that is, in the connecting tissue surrounding the secreting tubes. It causes primarily a swelling, with dilatation of the ducts and acini in its neighbourhood; later on projections of sarcomatous mammary tubes protrude into the already dilated ducts, so that a cystic growth is formed—a complicated cyst with winding glandular projections. The usual form met with is the round-celled, less frequently the spindle-celled sarcoma. Among the tumours arising from the epithelium of the gland the author described rare true adenoid tumours in which a morbid extension of the whole secreting structure took place with or without the formation of milk. Also partial adenoma (of which he had met with two instances); and lastly Billroth's epithelioma of the mamma, in which the epithelium is so excessively increased in quantity that the acini become enlarged to the size of millet seeds or even to a diameter of $\frac{1}{8}$th inch. Of this variety of tumour the author had met with one example—removed two years ago, and, so far, proving clinically innocent. He concluded by describing the minute anatomy of carcinoma of the breast. His observations were illustrated by a large collection of beautiful and well-selected specimens of sections of the healthy mamma of a girl, old woman, and man; of an epithelioma (Billroth's);

of an intracystic growth, or "hernia of adenoid mammary tissue;" of a fibrous tumour; of a round-celled sarcoma; and of carcinoma from eight different cases.

Dublin Microscopical Club.

25th September, 1873.

Sections of Miocene Zeolite-bearing Trap, exhibited.—Prof. Macalister exhibited a section of the Miocene Zeolite-bearing trap from Trotternish, Isle of Skye, showing the relations of the Labradorite, Augite, and Olivine crystals of which it is composed.

Spectroscopic examination of Crystals from a Cactus.—Mr. Tichborne stated that, since the previous meeting, he had at Dr. Moore's request, examined the crystalline masses, as they might be called, found by him in a species of Cactus. These had proved themselves to consist of oxalate of lime. When examined with the spectroscope the calcium bands were given in a striking manner, showing the value of this instrument for minute analysis. When the crystals were ignited they gave white opaque particles without blackening; these were seen to effervesce when treated on the slide with acetic acid. They were not soluble in acetic acid, but were so in hydrochloric acid, and the resulting solution gave a precipitate on the addition of ammonia. They were evidently, therefore, crystals of oxalate of lime.

Exhibition of Algæ from Hot-water Springs, Azores.—Mr. Archer exhibited some further examples of algæ and other organisms from the Azores gatherings made by Mr. Mosely. Amongst these was the alga ere now brought before the Club and spoken of as "Animated Sand" (see Club Minutes of July, 1871). He showed, too, a curious gemma-growth on a moss stem, resembling the 'radical tubercles' (tubercules radiculaires, Schimper), but he hoped to revert to this collection on a future occasion.

23rd October, 1873.

Structure of Ganoid bone of Ganorhynchus Woodwardi, Traquair.—Dr. Traquair exhibited a section of the ganoid bone on the surface of the fossil fish-snout, which he had recently described as *Ganorhynchus Woodwardi.* Though the fish belonged to the Order Dipnoi, and not to the Ganoids proper, the section exhibited characters essentially similar to those found in the polished plates and scales of many Ganoid fishes. When the section was taken the bone was very thin, being only about $\frac{1}{40}''$ in thickness. It showed first a thin superficial layer of structureless ganoine about $\frac{1}{1000}''$ thick; through this the punctures of the surface opened into a set of short vertical canals, widening downwards so as to assume a somewhat conical figure; these communicated with each other at their bases, and also with the close, irregular network of Haversian canals which ramified through the remaining inferior part of the

section. Below the ganoine the interval between the short vertical canals, more or less cup-shaped in the section, were seen to be, for the most part, traversed each by a short vertical tube coming up from the Haversian network below, and dividing in an arborescent manner into a multitude of minute ramifying tubules, passing towards, but not into, the ganoine above. The branches of adjacent trees of this kind also freely communicated with each other around and between the short vertical canals, between which their stems were situated. It must be noted, however, that osseous lacunæ were occasionally seen among its minute tubules. Lacunæ of the normal type abounded in the substance of the bone below.

"*Winter Egg*" *of Notommata.*—Mr. Crowe showed the "winter egg" of a Notommata-species, much resembling in external figure the zygospore of certain Desmids, its long spines dilated below, covering the surface and extending radially in all directions, the apices somewhat curved.

Irish Thysanura.—Dr. E. Perceval Wright exhibited a small collection of Thysanura made within the compass of a two-acre field at Howth, consisting of *Orchesella cincta*, *Tomoceros longicornis*, *T. plumbea*, *Lepidocyrtus curvicollis*, *L. purpureus*, *Degeeria nivalis*, *Isoloma anglicana*, *Lipura maritima*, and *Machilis maritimus*. Several of these had not previously been recorded as Irish. No group of Arthropods needed investigation more than this, and none required a more patient microscopical investigation to determine not only the limits of the species, but also of the genera.

In noticing the recent 'Monograph on the Collembola and Thysanura' by Sir John Lubbock, Dr. Wright pointed out a few errors, both of commission and of omission, that had struck him on a hasty glance over the volume; the typographical errors were not only very numerous, but in some places extremely puzzling.

Amœba with remarkable posterior linear processes.—Mr. Archer drew attention of the meeting to a remarkable and well-pronounced example of the same condition in Amœba once before shown to the Club (see Minutes of the Club, February, 1866), consisting in the projection from the *posterior* end of a number of linear prolongations of the body substance (like a bundle of *dip-candles*, if the candles were of varying lengths!). These prolongations or processes possessed a certain amount of temporary rigidity, and gave a very odd-looking appearance to the specimen; it was in active progression, and the behaviour (as regards flow of contents, locomotion, &c.) was quite that of an *A. villosa*.

Cosmocladium Saxonicum, de Bary, *exhibited.*—Mr. Archer showed examples from Connemara of the seemingly widely distributed, but always extremely scanty, alga, *Cosmocladium Saxonicum*, de Bary, drawing attention to the points dwelt upon by de Bary as distinguishing this form from *C. pulchellum*, Bréb., which latter had not appeared in this country. The supposition is, however, open that these *may* be one and the same thing, and the confusion (if any) due to a certain want of definiteness as regards de Brébisson's description and figure.

Zygospore of Micrasterias papillifera, for the first time found in Ireland.—Mr. Archer showed the zygospore of *Micrasterias papillifera*, Bréb. from Glencolumbkille, Co. Donegal. This rather common species, though not at all abundant, does not seem to have been met with conjugated since recorded by Ralfs. As is shown by that author, the zygospore is very like, though, of course, smaller than that of *Micrasterias denticulata*, Bréb., though the mature plant is quite dissimilar, and it is seemingly of interest to note this fact, seeing the very dissimilar zygospores of the latter and that of *M. rotata*, Ralfs, although these two forms, from possessing a considerable resemblance to one another, have ere now by some been held to be but varieties one of the other. The present examples formed exceedingly ornate objects.

New Species of Colpocephalum, exhibited.—Mr. H. W. Mackintosh showed a new species of *Colpocephalum* from *Ardea purpurea*, of which he would, ere long, prepare a figure and due description; its nearest ally was *C. flavescens.*—Dr. Macalister showed, as further illustrative of the genus and for sake of comparison, *Colpocephalum zebra.*

20*th November*, 1873.

Cosmarium Holmiense, β Lundell, *exhibited.* — Mr. Crowe showed a Cosmarium taken by him, in company with Dr. J. Barker, from a wet rock at the Falls of the Rhine, which turned out to be identical with *Cosmarium Holmiense, β* Lundell; this form has now been taken in Norway and Spitzbergen.

Sections from a puzzling Fern-like stem—a marine waif—exhibited.—Mr. Mackintosh showed sections made by him from a stem of fern-like or lycopod aspect, found cast ashore on the Kerry coast, and forwarded by Rev. M. H. Close; this was about nine inches long, about an inch in diameter, twice dichotomously branched, and densely covered in an imbricated manner by the scale-like bases of former leaves, the whole of a black colour. These sections showed scalariform vessels. The origin of this curious waif was quite unknown, the general opinion being that it was of fern nature.

Action of Chloroform on Hair affected by Porrigo decalvans.—Dr. Frazer showed the action of chloroform in bleaching hairs affected with *Porrigo decalvans* or true *ring-worm*, a reaction lately discovered by Dr. Dyce Duckworth. Under this reagent the diseased hairs and portions of the epithelium affected become of pale yellowish-white colour, and an excellent criterion is afforded of the extent of the disease.

Sections of Nail and Walrus Tooth, exhibited.—Mr. Pearsall showed with the polariscope sections of human nail and of walrus tooth.

Micrasterias furcata, found for the first time in Ireland, exhibited along with M. radiosa.—Mr. Archer showed two very rare forms (as Irish) of Micrasterias, from Co. Galway, viz. *Micrasterias furcata* (Ag.) and *M. radiosa* (Ag.). The former

he had never before found in Ireland, and had, indeed, only once before seen it from near Ambleside, in Westmoreland; the latter he had taken only once before in Ireland (Connemara). As previously mentioned, *Micrasterias furcata* (the handsomest British form!) was to his eyes quite a distinct thing from *M. crux-melitensis*, though, ere he had seen an indubitable example of *M. furcata*, he had conjectured they might possibly be one and the same.—*Micrasterias radiosa* he had taken previously in Wales, but only in Ralf's single locality for it, Llyn Gwernan, near Dolgelly, and once before in Ireland, (Connemara); Irish specimens did not seem quite so large as the Welsh.

Staurastrum arctiscon (Ehr.), Lund., *new to Ireland.*—Mr. Archer likewise showed, new to Ireland, from Connemara, that very fine form *Staurastrum arctiscon* (Ehr.), Lundell; of this, indeed, he had found only three or four examples, though he had most patiently gone over the material in the hope of increasing the number, and it is so large and striking a form it could hardly escape observation in an ordinary field of view, even under the lowest powers. It is quite distinct from *Staurastrum sexangulare*, Bulnh., upon taking which species for the first time Mr. Archer had thought to be *St. arctiscon* possibly.

Docidium coronatum, Ehr., *exhibited.*—Mr. Archer also showed the, with us, rare *Docidium coronatum* (Ehr.), a fine species, not unlikely, however, to be overlooked for *Docidium nodulosum.*

Heterophrys Fockii, Archer, *exhibited in groups.*—Mr. Archer showed a very fine collection, presenting many groups conjoined, sometimes as many as a dozen or so of individuals of *Heterophrys Fockii;* this rhizopod, when nicely illuminated, forming then a pretty and curious-looking object, calling to mind Haeckel's figure of *Myxodictyum sociale*, but it need not be said a wholly different thing. These examples showed the pseudopodia extended to a very great length; longer, in fact, than he had ever before seen, say three or four times the body-diameter.

Form of Navicula lyra (possibly a distinct species?)—Rev. E. O'Meara showed a form of *Navicula lyra*, Ehr., from stomachs of Ascidians (Roundstone Bay, Co. Galway), which in all its details coincided with the form described by Grunow, 'Ueber neue oder ungenügend gekannte Algen,' p. 532, t. iii, f. 22. The striation is minutely but distinctly punctate and quite unlike that of the well-known forms of *Navicula lyra.* On this ground he considered it as a well-marked variety thereof, but not entitled to be considered as a distinct species.

18*th December*, 1873.

Closterium linea, Perty, *exhibited.*—Mr. Crowe showed *Closterium linea*, Perty, from the little *Stephanosphæra*-pool on Bray-head, the first time that that species had been met with in that restricted site.

A Form of Navicula didyma, W. Sm. (*possibly a distinct species?*), *exhibited.*—Rev. E. O'Meara showed a form he considered identical

with *Navicula didyma*, sporangial variety, W. Sm., 'Brit. Diat.,' vol. i, t. xvii, f. 154, *a*. This bears a strong resemblance to *N. Smithii*, var. *fusca*, Greg., so that it is not surprising that some should have identified it with the last-named species. A close inspection, however, of the peculiarities led him to the conclusion that it is quite distinct. The central panels in both are somewhat rhombical, and the striation in this portion very similar, apparently costate; *Navicula fusca*, indeed, in some aspects, appears slightly incurved at the sides, but this is plainly constricted. In the former the general striation is moniliform—in the latter it consists of somewhat elongated lines, and much coarser than the other species.

Nostochaceous filaments in tissue of Azolla, exhibited.—Professor M'Nab exhibited an illustration of the presence of Nostochaceous filaments in the tissue of higher plants, an occurrence recently drawn attention to by observers (Reinke and others), as exemplified by *Azolla*. These he had extracted from the tissue and placed under the microscope, stating that, on looking over the collection he possessed of different *Azolla*-species, all had shown him the presence of these algæ within their tissue, adverting also to the fact that, whilst these had for some time been noticed, they had been by certain observers interpreted as in some way connected with the reproductive apparatus of the *Azolla*. The presence of foreign algæ forms within the tissue of higher plants had lately acquired a double interest, that which attached to their living and seemingly flourishing in so unexpected a habitat, as well as that which these "parasitic" algæ, so called *ad interim*, had in relation to the new theory of the nature of "lichen-gonidia" propounded by de Bary and Schwendener.

Illustrations of the Reproductive Apparatus in Marchantieæ.—Dr. Moore exhibited plants of *Morckia hibernica*, Gottsche, and *Petalophyllum Ralfsii*, Gottsche. The latter had the male and female flowers in good condition. Groups of young archegonia ready for impregnation, and some impregnated, were shown. Dr. Moore mentioned that he had seen numbers of the thread-like bodies like spermatozoa floating about among the archegonia, but could not observe that they entered at the apex of those bodies. The observation was made with a moderately good French $\frac{1}{8}$ object glass. On another slide Dr. Moore had the male flowers of *Lunularia vulgaris*, which, he observed, were in good condition at this period of the season. He further observed that when the male flowers are fully ripe, if the plant be put into a pan or saucer and covered over with a pane of glass, a quarter of an inch or so apart from the surface of the plant, the glass, though well cleaned when put on, will after a few days become discoloured. If the substance which causes this be gently scraped off and put on a slide with a little water, and covered with a covering glass, it will be found to consist chiefly of the ovate antheridia, which led him to conjecture that those minute organisms are ejected from their cavities on the surface of the thallus by a jerk. He had not seen this take place, but he could not account otherwise for this being on the surface of

the glass, which was so far apart from the plant. The phenomenon can also be well observed in plants *Fegatella conica*, Corda.

Bulbochæte minor, Prings., *exhibited in fruit* (*mid-winter*).—Mr. Archer showed examples in various more or less developed and nearly perfect fruit of *Bulbochæte minor*, Pringsheim, possibly possessing an additional interest as being taken in fruit in midwinter. The commencing formation of the oogonia and variously advanced stages were well seen, also of the antheridia. The fully-formed oogonia showed the characteristic longitudinal ribs; further, what seemed to be a new character was noticeable in some empty specimens, that these ribs were connected by numerous transverse, though delicate, lines, giving a scalariform appearance.

East Kent Natural History Society.

Honorary Secretary, George Gulliver, F.R.S.

October 2nd, 1873.

Crystals in Leguminous Plants.— The Hon. Sec. exhibited drawings and preparations, and gave practical demonstrations in the fresh plants, of the crystals of oxalate of lime which he had discovered in the leaves, pods, liber, and other parts of Leguminosæ, since illustrated by a plate in the December number of the 'Monthly Microscopical Journal.' These crystals, mostly belonging to one or the other of the prismatic systems, he calls *short prismatic crystals*, thus distinguishing them from raphides, sphæraphides, long crystal prisms, or other forms of plant-crystals. The short prismatic crystals resemble those in the testa of the elm, described and figured in last July number of the 'Quarterly Journal of Microscopical Science,' and are about $\frac{1}{3000}$th of an inch in diameter, and occur very abundantly in chains of cells along the fibro-vascular bundles of the leaves, calyx, and pods, and also scattered throughout many membranous parts. In one inch of one vein of a single leaflet of clover he counted no less than 17,500 of the short prismatic crystals; and his lecture was concluded by observations on the significance of these crystals in the economy of animals and plants.

Dentate Scales of Pleuronectidæ.—Mr. Hayward showed some prepared slides of the notched scales (ctenoid) of the sole, being a good example, contrary to the rule, of this form of scale in soft-finned fish.

November 6th, 1873.

The late Major William Augustus Munn.—Referring to the recent death of this eminent apiarian, and the loss which his widow and family and entomological science had sustained thereby, a motion expressive of the sympathy and regret of the society, of which he had long been a most valuable member, was unanimously carried.

Statoblasts of Plumatella.—Colonel Horsley remarked the abundance of *Plumatella repens* about Canterbury, and how easily this beautiful species may be kept in the aquarium. This had enabled him to confirm Dr. Allman's observations, that the statoblasts are not ova, but a peculiar form of bud produced in the funiculus. The Colonel exhibited the statoblasts under the microscope, and suggested, for future research, the question as to how far they may admit of comparison with the winter ova of Rotifera, and the ephippia of Daphne.

Hydras and their Prey.—Mr. Fullagar showed many live specimens of *Hydra viridis* and *Cyclops quadricornis.* When the Cyclops was put to the Hydra, the former was instantly taken by the latter, sometimes ingested immediately, and often only seized or touched by the polyp's tentacles, and allowed to float away. But in either case the death of the prey was sure, as proved in many trials. Hence he concludes in the affirmative as to the vexed question of the power of the fresh-water polyp to destroy its prey by mere stinging.

December 4th, 1873.

Eggs of Fresh-water Polyps.—Mr. Fullagar exhibited and made some observations thereon. The ovum of *Hydra vulgaris* is of an orange colour, and about $\frac{1}{66}$th of an inch in diameter; the ovum of *Hydra viridis* is of a light brown colour, and about $\frac{1}{50}$th of an inch in diameter; these ova of both species are spherical. An egg of *Hydra viridis*, detached from the parent towards the end of May, was hatched in his aquarium about thirty days thereafter.

Utricular Hairs of Chenopods.—The Hon. Sec. showed, by drawings and preparations, that the so-called mealiness of these plants is produced by simple hairs of two or three cells, the terminal cell being dilated into a globular vesicle, numbers of which so reflect the light as to produce the mealy appearance. By transmitted light they appear colourless and transparent. The dilated terminal cell is about $\frac{1}{266}$th of an inch in diameter.

Calcareous granules on Bryonia dioica.—These, commonly described by botanists as "asperities" or "callous points," he proved, by extemporaneous preparations and experiments, should be rather called *Calcareous granules;* for this is their true nature, as they are composed of carbonate of lime. Each callous point is about $\frac{1}{114}$th of an inch in diameter, and the smooth, shiny, constituent granules composing that point have an average size of $\frac{1}{666}$th of an inch. This profusion of calcareous matter on the surface of the leaf of bryonia is remarkable, as this plant is throughout devoid of any raphides, and contains an unusually small number of other saline crystals.

Sphæraphides and Epidermis of the leaf of the Tea Plant.—The public mind being now much interested about the adulterations of tea, the Hon. Sec. gave some demonstrations, and exhibited preparations of the leaf of a fresh plant of *Thea viridis.* The

epidermis on both sides of the leaf was shown to be composed alike of cells with sinuous margins (colpenchyma), with the addition to the epidermis on the under surface of oval stomata, and shortish, smooth, taper, slightly curved hairs. Throughout the parenchyma of the leaf were sphæraphides, thickly studded, and with a mean diameter of about $\frac{1}{1000}$th of an inch; and here and there were short strings of similar sphæraphides, only about half as large, on the fibro-vascular bundles. The composition of the sphæraphides appears to be chiefly oxalate of lime. They are not easy to find, in consequence of the density and opacity of the surrounding parts; and this is probably the reason why these beautiful crystals have hitherto escaped discovery.

Value of Potash in Histological Phytotomy.—At the same time he remarked that the value of potass in separating the fibres, membranes, or cells, and clearing parts of plants for microscopical investigation, seems to have been insufficiently appreciated. He showed, for example, that by treatment with cold solution of this alkali, and still better by boiling in it portions of the tea leaf, the epidermis could easily be detached from both sides, leaving quite distinct the intervening layer of parenchyma and nerves, and thus beautifully exposing the sphæraphides. He had found the potass equally useful in disclosing the short prismatic crystals in leguminous and many other plants, and in examination of the tea of commerce; so that the heretofore refuse of the teapot may be made a very interesting subject for microscopical inquiry.

MEMOIRS.

On the Term Endothelium. By Michael Foster, M.D., F.R.S., Prælector in Physiology, Trin. Coll., Cam.

The word "endothelium" has been recently introduced into histology, and the use of it has rapidly become common, if not general. The speedy acceptance of a new term may, in many cases, but not in all, be taken as an indication that something of the kind was wanted; and the already frequent use of "endothelium," both by Continental and English histologists, would seem to show the need of some other phrase besides "epithelium." Nevertheless, there are cogent reasons why the new term should not be allowed to take any further root.

In the first place, its etymology is of the most grotesque kind. This is of course an objection of secondary value; but still it carries some weight. When a term has come into daily use, with a clear, well-defined meaning attached to it, it does not matter much what its etymology is or how it is spelt, except on historical grounds. Many terms get so altered in their meanings before they finally acquire a permanent application, that the chief interest in their etymology is confined to the light it throws on the ideas of the man who first introduced them. This is the chief reason why new terms should be etymologically correct, in order that future inquirers may read back through them into the minds of earlier observers. When a word is etymologically pure nonsense, this is apt to become impossible. Such is the case with endothelium.

It appears to have been first introduced by His, to designate the kind of epithelium (pseudo-epithelium, *unächte epithelien*") which is found lining the vascular, lymphatic, and serous cavities of the body, in contradistinction to the real epithelium of mucous membranes. He says (*Die Häute und Höhlen des Körpers. Academisches Programm. Basel*, 1865, *p.* 18):—

Alle die Zellenschichten, welche den Binuenräumen des mittleren Keimblattes zugekehrt sind, zeigen nun aber unter sich so viel Gemeinsames und sie differiren von der ersten Zeit ihres Auftretens auch so erheblich von den Zellenschichten, die aus den beiden Gränzblättern hervorgegangen sind, dass man, im Interesse physiologischen Verständnisses wohl thun wird, sie von diesen durch eine besondere Bezeichnung zu scheiden, sei es, dass man sie als *unächte Epithelien* den *ächten* gegenüber stellt, sei es dass man sie *Endothelien* neunt um mit dem Wort ihre Beziehung zu den innern Körperflächen auszudrücken.

Endothelium is here contrasted with epithelium, so that the latter may be considered as the "thelium" of free surfaces (whether invaginated or not), and the former as the "thelium" of internal closed spaces; "thelium" apparently being taken to mean "a layer or layers of cells."

Now, what is the derivation of "epithelium?" I am indebted to Dr. Sharpey for the following account. He says, in a letter to me:—"*Epithelium*, or rather '*epithelida*,' and especially '*epithelia*' (first declension), was introduced by F. Ruysch. In describing a preparation of the face of a child finely injected, he refers to the cuticle over the red part of the lip (prolabium), and says, 'I cannot call this "epidermis," seeing that the subjacent tissue is not skin, but a different substratum covered with sensitive (nervous) papillæ, which are finely injected red.' He then goes on to say that as the cuticle lies on papillæ he will call it *epithelida*, or *epithelia*, from επι and θηλη, 'papilla' or 'mammilla,' and he adds that for the same reason he calls the inside coating of the cheeks by the same name. The original is as follows (Ruysch, F., 'Thesaurus Anatomicus III,' No. xxiii, p. 16):—

"'* * * Nulla sabest huic integumento cutis, ergo epidermis dici nequit quamvis analogiam summam et connexionem cum illa habet * * * * comperi prolabia constituta esse ex meris papillis non cutaneis (cutis enim hic revera deest) sed papillis nervosis; itaque integumentum illud supradictum potius epithelida dixero vel integumentum papillare prolabiorum quod revera nil est nisi efflorescentia seu expansio extremitalum papillarum.'

"In 'Thesaurus Anatomicus VI,' No. cxv, p. 49, he says, 'Anterior pars prolabii inferioris—*epithelia* adhuc est obducta.'"

From this it is evident that epithelia, changed in course of time into epithelium, just as platina has become platinum, means "that which covers or is upon a papilla," and conse-

quently endothelium means "*that which is inside a papilla.*" The extension of the phrase epithelium to the cellular covering of such parts of the corium as are destitute of papillæ may be easily allowed, but it does seem a most daring defiance of all meaning of words to apply the phrase "within the papilla" to the cells *coating* surfaces of which one great characteristic is that they are devoid of papillæ! There seems to be something attractive about "thelium" that tempts writers to make use of it. Already endothelium has given rise to a new "ectothelium," and probably after a few years "thelium" will become a sort of histological maid-of-all-work, with as many prefixes as there are kinds of cells.

In the second place, there are objections to the use of endothelium not etymological in their nature.

The peculiar views of His on the origin of the connective tissues of the body would, if true, afford a strong argument for the use of some special term to denote such kinds of epithelium as were formed out of his parablast. Putting these aside as mistaken, there still remains the question whether it is not desirable to have some distinctive appellation to denote the epithelium which is formed out of the elements of the middle of the three layers of the germ (the *mesoblast* of Mr. Huxley and myself), the word epithelium itself being reserved for the nether layer (or *hypoblast*).

If so, the word endothelium cannot be employed with this meaning, for it would then include structures still called epithelium, and differing in no essential characters from the epithelium derived directly from the hypoblast.

The cells lining the Wolffian duct, and its derivative the ureter, with their branches, would then come under the heading endothelium. Whatever be the exact mode of the first formation of the Wolffian duct, whether by the central solution of a solid ridge, or by an infolding of the lining of the pleuroperitoneal cavity, it is lined by cells which are clearly mesoblastic in origin, not hypoblastic nor, as was once suggested, epiblastic.

The case of Müller's duct is still more clear. This undoubtedly arises by an infolding of the lining of the pleuroperitoneal cavity. Its epithelium is distinctly mesoblastic in origin. The germinal epithelium which gives rise to the ovaries is also essentially mesoblastic.

If the word endothelium, then, be taken to denote an epithelium derived from the mesoblast, it must be extended to include the epithelium of the Wolffian and Müllerian ducts, and of the parts which are formed ultimately out of those structures. But if these be included, the phrase loses all its

practical utility. If they are excluded, all the little meaning it ever had vanishes.

It may be urged that we need a word to denote the epithelium which is found in the vascular and lymphatic spaces. There does not, however, appear to be sufficient reason why the same term should be applied to the whole of this epithelium. As we have seen, its common mesoblastic origin will not justify this. From a structural point of view, three distinct varieties may be recognised in it, viz. the spindle-shaped cells of the blood-vessels and larger lymphatic vessels, the sinuous cells of the commencing lymphatics and the polygonal cells of the large serous cavities. The fact that the epithelium of the peritonæum is continuous with that of the lymphatics affords no argument whatever for classing them together. We find continuity everywhere. The epidermis is continuous with the alimentary epithelium, and with the urinary and generative epithelium; and the generative epithelium is in turn continuous with the peritoneal epithelium. In short, there is no reason why the cells spoken of as forming endothelium should have a common title, distinct from the general term epithelium.

The introduction of the new term is really a step backwards from instead of an advance beyond the old classification adopted by Dr. Sharpey in Quain's 'Elements of Anatomy.' He divides epithelium either physiologically into epidermic, mucous, glandular, vascular, serous, &c., or structurally into columnar, spheroidal, ciliated, tesselated, squamous, &c.

Surely some such nomenclature as this satisfies all requirements, either morphological or physiological, at least for the present.

The chief morphological importance, as far as our knowledge goes, attaches itself to the question from which of the three primary layers any given epithelium is derived, whether from epiblast, hypoblast, or mesoblast; and it is precisely because the phrase endothelium is in this respect misleading that its use is so undesirable. Beyond this, it is difficult to see any morphological interest, unless future research should show that in the common mesoblast there are factors morphologically distinct. When that is clearly shown, it will be time to invent new terms which may be as lasting and as valuable as ectoderm and entoderm.

For physiological purposes all we need is some system of phrases which shall clearly indicate the individual characters and the arrangement of any group of cells. The few terms, "columnar" or "cylindrical" and "spheroidal," either "ciliated" or "non-ciliated," are almost all we want for

mucous membranes in general. The word "squamous" sufficiently clearly indicates the general character of an epithelium made up of flattened cells which overlap, as "tesselated" equally clearly signifies an epithelium of flattened cells fitting into each other at their edges. These are general distinctions. Such special forms as the sinuous cells of the commencing lymphatics or the jagged cells of the epidermis do not need any distinctive general appellation.

We perhaps do want easy terms which shall denote whether the epithelium in any spot consists of several layers, or of one pronounced layer only. The latter might be called *monoderic* (δερος = δερμα), the former *polyderic.*

Epithelium itself would simply mean cells lining a cavity or coating a free surface.

The GASTRAEA-THEORY, *the* PHYLOGENETIC CLASSIFICATION *of the* ANIMAL KINGDOM *and the* HOMOLOGY *of the* GERM-LAMELLÆ. By ERNST HAECKEL. (Translated by E. PERCEVAL WRIGHT, M.D., F.L.S., Sec. R.I.A., Professor of Botany, Trin. Coll., Dublin. With Pl. VII.)

(*Continued from p.* 165.)

5.—THE SYSTEMATIC SIGNIFICATION OF THE GASTRAEA THEORY.

THE following conclusions relating to the natural system of the animal kingdom, or, what is the same thing, to its genealogical tree, result from the foregoing discussions, which I have already explained, partly in the 'Biology of the Calcareous Sponges' and partly in the fourth edition of the 'Naturliche Schöpfungsgeschichte' (in the eighteenth lecture). The whole animal kingdom divides into two large principal groups, the gastrula forming the separating boundary line between them; on the one side the stem-group of the primary animals (*Protozoa*); on the other, the six higher stem-groups which we oppose to the others as animals with germ-lamellæ (*Metazoa* or *Blastozoa*). In the primary animals (the Protozoa) the entire body consists either (1) of a simple cytode (Monera, Monothalamia), or (2) of an aggregate of cytodes (Polythalamia), or (3) of a simple cell (Amœbæ, unicellular Gregarinæ, Infu-

soria), or (4) of an aggregate of simple, similar cells (poly-cellular Gregarinæ, Synamœba), or, lastly (5), those where the cells of the body may even be differentiated to a slight extent, but which still form no germ-lamellæ, and enclose no true intestinal cavities. The individuality of the Protozoa always remains fixed at a very low point; that is, they either form a morphon of the first order, a simple plastid (a cytode or a cell), or they form, at most, a morphon of the second order, an "organ" in a purely morphological sense, an idorgan (see the doctrine of individuality in the 'Biology of the Calcareous Sponges,' p. 103, &c.). But the Protozoa never raise themselves to the importance of a morphon of the third or fourth order, a Person or a Stock (in the sense defined in the passage quoted). Just as a true intestine (the first and oldest organ of the germ-lamellar animals) is wanting in the Protozoa, so are absent also all the differentiated systems or organs which we find in the former. The Protozoa have no nervous system, muscular system, vascular system, dermal system, &c. They also want the differentiated tissues.

On the important grounds which I have fully developed in the second volume of the 'General Morphology' and in my 'Monograph of Monera,' it seems to be a real advantage, especially towards the comprehension of general biology, to separate a large portion of the so-called Protozoa from the animal kingdom, and to relegate them to the neutral kingdom of Protista, intermediate between the animal and vegetable kingdoms. To this would belong part of the Monera, the Amœboida, and Flagellata, in addition to the Catallacta, the Labyrinthulea, the Myxomyceta, and the entire class, so rich in forms, of Rhizopoda, with all its different divisions; Acyttaria, Radiolaria, &c. All these Protista are to be regarded as independent organic stems or phyla, which do not stand in any kind of genealogical connection with the animal kingdom, and consequently do not belong to its natural system. On the other hand, there are very simple organisms which either belong to the actual stem-forms of the animal kingdom, and form the true root of the animal genealogical tree, or represent independent offshoots from that root, as well as those very simple organisms which display an undoubtedly animal character (as the Infusoria), which are to be separated from these neutral primary forms or Protista as true primary animals or PROTOZOA. These Monera and Amœbæ should be regarded as true primary animals, representing the oldest stem-forms of the animal kingdom, and I have classed these in the fourth edition of the Schöpfungsgeschichte

as egg-animals (Ovularia), because they possess a shape corresponding to the simplest (nucleus-containing) egg-cell or the egg-cytode (without nucleus). With these must also be reckoned the planula representing animal forms (Planæada), and, finally, the Gregarinæ, the Acinetæ, and the true ciliated Infusoria (Ciliata).

The second main division of the animal kingdom is composed of the six higher stem-groups, which are all derived from the common stem-form of the Gastraea. We class them together as germ-lamellar animals, METAZOA (or Blastozoa), or animals with an intestine (Gastrozoa). In all these animals, from the sponges up to the Vertebrata, the body always originally develops itself from two primary germ-lamellæ, the animal exoderm, and the vegetative endoderm. The latter always encloses a true intestinal cavity with a mouth-opening.[1] Therefore the body has the form-value of a morphon of the third order, a true person, or is composed of several persons, and is then an individual form of the fourth order, a stock ('Biology of the Calcareous Sponges,' p. 103, &c.). All these germ-lamellar animals possess at least two different systems of organs, namely, the dermal system (the covering of the outer germ-lamellæ with its derivatives) and the intestinal system (the intestinal outfolding of the inner germ-lamella with its derivatives).

In further classifying the Metazoa, we may, in the first place, advantageously make use of three different principles of division—1. The want or possession of the cœlom. 2. The different number of the secondary germ-lamellæ. 3. The radial or bilateral fundamental form.

If we would attach a principal importance to the cœlom and the vascular or blood system depending upon it, then the main division Metazoa divides next into two distinct groups; on the one side the lower germ-lamellar animals without cœlom or hæmolymph; Zoophyta and Acœlomi (Plathelminthes); on the other the higher Metazoa with cœlom and hæmolymph; the Cœlomati and the four highest groups of animals springing from these—Echinodermata, Arthropoda, Mollusca, and Vertebrata (*vide* the 'Biology of Calcareous Sponges,' pp. 467, 468). We could adopt for these two groups the original terms, in their strictest sense, of Aristotle, Anæma

[1] The few animals among the Blastozoa which are without an intestine, the Cestoda and Acanthocephala, cannot be considered here as an exception, as they have apparently lost the intestine in consequence of their parasitic habits, and originally sprung from worms provided with an intestine. This follows, unquestionably, from their comparative anatomy and ontogenesis.—*Vide* 'General Morphology,' vol. ii, p. lxxx.

and Enæma (but in any case not with the expressed limits of their author). Anæma or true "bloodless" Metazoa are the Zoophyta and Plathelminthes (Acœlomi). Enæma or true "blood animals" are, on the other hand, the Cœlomati (worms with blood and cœlom), and the four highest animal races arising from these. The former could be defined as *Anæmaria* and the latter as *Hæmataria.*

The attempt to employ the number and differentiation of the constituent germ-lamellæ, as the fundamental principle of division for the main groups of the animal kingdom, has very recently been twice carried out in different ways by Gustav Jaeger and E. Ray Lankester. The first gives in his suggestive 'Manual of General Zoology' (1871) a special chapter on the "Principles of the Layers and of the Groups of Layers: Stratography of the Animal Body." Jaeger separates here—1. Two-layered animals ("the lowest multicellular animals"). 2. Three-layered animals (Cœlenterata). 3. Five-layered animals (Enterata or animals with intestines; our Bilateria, the five higher groups of animals). Praiseworthy as the attempt is, to apply "stratography" in this manner to animal morphology, it must yet be regarded as misleading in details. This becomes at once apparent by comparing Jaeger's explanation (especially §§ 55, 67) with our explanation in the present essay, which has the Gastraea-theory for its basis. Just as little can I concur in details with the attempt of E. R. Lankester (loc. cit., p. 325). He divides the animal kingdom into—1. Homoblastica, without differentiated germ-lamellæ (Protozoa). 2. Diploblastica (with two germ-lamellæ (Cœlenterata). 3. Tripoblastica, with three germ-lamellæ (the five higher groups, our Bilateria).

In our own opinion, if a man wished to characterise in this way the main groups of the animal kingdom by the number of the germ-lamellæ, he would do much better to separate them into the following four or five sections:—1. Ablasteria: Animals without germ-lamellæ (*Protozoa*). 2. Diblasteria: Animals with two permanent germ-lamellæ (*Gastraeadæ, Spongiæ,* and the lowest *Acalephæ*). 3. Triblasteria: Animals with three germ-lamellæ (the bulk of the *Acalephæ—Hydromedusæ, Ctenophoræ,* Corals). 4. Tetrablasteria: Animals with four germ-lamellæ (cuticular nervous and muscular layers, and intestinal muscular and glandular layers). The Bilateria, or the five higher groups of animals collectively. Among these last the Acœlomi (the worms without body-cavity or blood, the Plathelminthes) would represent the lower condition of development, from which the Cœlomati (the worms with body-cavity and blood) have subsequently developed them-

selves by the shrinking apart of the two muscular layers. The four highest groups of animals, the Echinodermata, Arthropoda, Mollusca, and Vertebrata, are diverging descendants of the four different forms of Cœlomati. It is not difficult to derive these four typical phyla from the common root-group of the worms. Their comparative anatomy and ontogenesis still shows us, even now, that they have near relatives among the Cœlomati. The Annelida lead to the Arthropoda and Echinodermata, the Bryozoa (?) to the Mollusca, the Tunicata (Ascidia) up to the Vertebrata (*vide* Lecture 18 in the 'Natürliche Schöpfungsgeschichte). If we wish to regard the cœlom (which has originated by separation of the animal and vegetative muscular layer) and the cells which belong to it (cœlom-epithelia, lymph-cells, blood-cells) in Jaeger's sense as representatives of a special fifth layer, an intermediate fifth germ-lamella, we should have to refer the Acœlomi only (Plathelminthes), and perhaps a portion of the Acalephæ, to the Tetrablasteria. On the other hand, all the animals provided with a cœlom (the Cœlomati and the four highest groups of animals) would form a special fifth main group: Pentablasteria, with five germ-lamellæ or principal layers of tissues:—1. Cuticular nervous layer. 2. Cuticular muscular layer. 3. Cœlom layer, or lymph layer, vascular layer in a modified sense. 4. Intestinal fibrous layer. 5. Intestinal glandular layer.

An arrangement of these five principal groups of the animal kingdom, with their known and generally accepted "types," would yield the following results:

1 Ablasteria . . .	1	Protozoa .	Protozoa	Protozoa.
2 Diblasteria . . .	2	Gastraeada .	Zoophyta	Metazoa.
		Spongiæ .		
3 Triblasteria . .	3	Acalephæ .		
4 Tetrablasteria . .	4	Acœlomi .	Vermes	
		Cœlomati .		
5 Pentablasteria .	5	Mollusca .	Typozoa	
		Echinodermata		
		Arthropoda		
		Vertebrata .		

However attractive it may appear to us from a phylogenetic point of view, to employ the number and differentiation of the germ-lamellæ in this manner as a basis for the classification of the animal kingdom, yet on a closer examination important obstacles present themselves, which do not justify the strict carrying out of this principle of division. Independently of the fact that we do not yet know the ontogenesis of many animals (especially of the lower orders) at all sufficiently, there are intermediate transitional forms between the five

groups mentioned, which admit of no sharp division, and, moreover, cases occur in the lower phyla of the Metazoa, in which nearly related forms of one stock must be placed in different groups of Blasteria. Although most of the Acalephæ (Hydromedusæ, Ctenophoræ, Corals) are probably blasteria, yet Diblasteria are among their lower forms (Hydra), and probably many Tetrablasteria are among their higher forms. Among the Acœlomi (Plathelminthes) probably many Triblasteria, or even Diblasteria, may be found among the predominating Tetrablasteria forms; and so in other cases.

On these and other grounds it appears much more preferable to employ only characters drawn from the phylogenesis of the Metazoa as the leading principle for their further division, in which the stereometric (radial or bilateral) essential form of the parts of the body plays a decisive part. The further development of the gastrula here appears next defined. Following this I have already arrived at the opinion (in the 'Biology of Calcareous Sponges') that the descendants of the Gastraea, as the common root-form of all the Metazoa, subsequently divided into two branches, the Protascus, which is to be regarded as the root-form of all the Zoophyta, and the Prothelmis, which is to be regarded as the common root-form of all the five higher groups of animals. The division of these two principal branches is quite mechanically dependent on the two different modes of life to which the descendents of the monaxial (neither "radiate" nor "bilateral") Gastraea first adapted themselves. The one group resigned the freely moving habits of the swimming Gastraea, attached itself by the pole of the axis of its body opposite to its mouth, and then developed *eo ipso* further into the so-called "radiate type" (Zoophyta). The other group of the descendant of the Gastraea retained the power of moving freely from place to place, proceeded from the swimming method of moving to creeping on the sea-bottom, and developed *eo ipso* into the so-called "bilateral type" (the five higher groups of animals, Vermes and Typozoa). I therefore regard only on the one side the fixed habits of life in the root-form of the Zoophyta (Protascus) as the mechanical "acting cause" of their radiate type, or, more correctly expressed, of their actinote (regularly pyramidal) essential form; and, on the other side, the creeping habits of life in the root-form of the worms (Prothelmis) as the mechanical *causa efficiens* of its bilateral type, or, more correctly expressed, of its dipleural (amphithect-pyramidal) fundamental form. This has been inherited from the worms by the four highest stem-groups of animals.

On the ground of this phylogenetic consideration we can class together the whole of the originally bilateral descendants of the Gastraea (the successors of Prothelmis) in a natural main group, which we will briefly designate Bilateria or Sphenota ("wedge-animals," on account of their wedge-shaped essential form in the sense of Bronn). This group includes all the worms and the four highest groups of animals derived from them; the Mollusca, Echinodermata, Arthropoda, and Vertebrata.[1]

6. Signification of the Gastraea-Theory in respect to the Homology of Types.

By comparing the germ-lamellæ in the different groups of animals we are led to the important question, how far the organs and systems of organs in general are capable of a morphological comparison in the seven phyla of the animal kingdom, and how far a true homology in the strictest sense (*i. e.* homophyly) is to be carried out between them? Those who maintain Baer's and Cuvier's doctrine of types in its original rigid sense, and consider all the types of the animal kingdom as perfectly separated morphological units, must naturally answer this question generally in the negative. Those, on the other hand, who regard the theory of types in the light of the theory of descent, and those who admit the modification of it, which we have attempted here by the Gastraea-theory, as well as the generalisation of the germ-lamellæ theory which depends upon it, must, to a certain extent, agree to such a morphological comparison. In fact, Gegenbaur[2] has recently expressed himself in this sense, and Kowalevsky[3] also in his latest work.

Although this question about the homologies of the groups of animals is extremely important and interesting for comparative anatomy and phylogenesis, yet its positive solution seems difficult and entangled in the present imperfect

[1] In all the Vertebrata, Annulosa, and Mollusca, the dipleural or bilateral essential form is just as undisputed as in the Vermes. But the root-form of the Echinodermata possesses also the same fundamental form. According to our theory of Echinodermata we consider as such the articulated worm-person which has still preserved most of its independence in the "Arm" of the Asterida. The radiate form of the developed specimens of Echinodermata (star-shaped Cormi, composed of five or more Persons), therefore forms just as little of an objection as the radiate form of specimens of the Synascidian stock (Botryllus).

[2] Gegenbaur, 'Grundzüge der vergl. Anatomie,' ed. 2, p. 82.

[3] Kowalevsky, 'Embryologische Studien an Würmern und Arthropoden, 1871, conclusion.

condition of morphology. I therefore lay no more stress on the following explanation than that of a provisional attempt. The phylon of the Protozoa is naturally entirely excluded from this consideration, as, according to our previously expressed opinion, no animal of this root-group rises to the formation of germ-lamellæ, and therefore the organs developed from the latter are also completely absent in the Protozoa. We therefore, for instance, consider any morphological comparison of any part of the body of an infusorium with an apparently representative (and physiologically, perhaps, equally important, and therefore analogous) portion of a germ-lamellar animal as quite inadmissible. As I have already shown in an essay "On the Morphology of the Infusoria," the intestine of the Ciliata can, for instance, be looked upon as such and compared with the intestine of the Metazoa. But in a morphological aspect these parts cannot generally be compared at all. The intestine of the Ciliata is but a portion of a single highly differentiated cell; the intestine of the Metazoa is a cavity enclosed by the many-celled inner germ-lamellæ. Homologies can only exist between the six stem-groups of the Metazoa, which are all derived from the Gastraea.

As the most certain and universal homology which is applicable throughout the whole series of Metazoa (from the sponges to the vertebrates), we may take the comparison of those organs which are already differentiated in the simplest Metazoa (the Gastraeada and the lowest sponges), and which persist in them throughout their lives in their simplest condition; that is, firstly, the primitive intestinal canal with its epithelium (the intestinal glandular layer, the entoderm of the gastrula); and, secondly, the most superficial covering of the body (the cuticular layer or the epidermis, the exoderm of the gastrula). With reference to this latter, it is expressly to be noticed that, indeed, the originally complete homology of the epidermis in the six phyla of the Metazoa may be unsatisfactory and frequently disturbed, in consequence of earlier commenced cuticular processes, by which the original outer epidermis layer is changed or stripped off into a transitory embryonal covering (as in Hydra, Kleinenberg), but that none the less the epidermis constantly retains at least a layer of cells, and serves as a foundation for the others, consequently the epidermis, as a whole, and as a derivative of the simple exoderm of the gastrula, is homologous in all the six stem-groups of the Metazoa.[1]

[1] The formation of many embryonal coverings, which arise ontogenetically from the uppermost germ lamella (the horny layer), is perhaps to be explained

The question of the homology of the central nervous system is much more difficult. This has, doubtless, arisen from the exoderm in all six stem-groups of the Metazoa, but the central nervous system of the zoophytes has certainly arisen independently of that of the worms, and is in no respect to be compared to it. On the other hand, the simplest form of the central nervous system, which is found in the worms, especially the simple pair of ganglia lying over the œsophagus, the so-called upper pair of ganglia or primitive brain, is to be regarded as homologous, firstly, in all classes of the group of worms, and, secondly, is to be compared also to the corresponding parts in the Mollusca and Arthropoda, as well as to the original medullary tube of the Vertebrata (from which the brain of the latter is only the furthest differentiated division[1]). This original central organ has been lost in the Echinodermata, and their œsophageal ring is only a secondary commissure between the five radial nervous threads, which appear in the Asterida in their most original form. Each of these five radial threads of the Echinodermata is homologous to the jointed ventral cord of the Annelida and Arthropoda. It is necessary to accept the correctness of my theory of the origin of the Echinodermata for the conception of this apparently paradoxical comparison, according to which the root-form of the phylon of the form of the Asterida is to be regarded as a stem composed of five-jointed worms united into a star-shape. This theory has, indeed, been rejected by Claus, Leuckart, Semper, and others, but without their putting any other

phylogenetically by moultings (or "Mauserungen") which the ancestors of the organism in question have suffered in earlier periods of the earth's history. So is, especially, to be explained the larval form of many of the higher Crustacea, which originates within the egg-shell, and is itself frequently changed, upon repeated moultings of the root-form of the Crustacea, the Nauplius, and other old root-forms which have arisen from this. (Compare the statements and explanations relating to this in the detailed works of Fritz Müller, Edouard von Beneden, A. Dohrn, &c.) This is, perhaps, also the explanation of the so-called Amnion in many animals. On the other hand, the amnion of the vertebrata is certainly of a different origin. As for the special homology of this amnion in Vertebrata and Arthropoda, as maintained by Kowalevsky and others, it is already contradicted, independently of other reasons, by the fact that the amnion only occurs in the three higher classes of Vertebrata (Amniota). This has, therefore, apparently first developed itself here, during the origination of the root-form of the Amniota from the Amphibia, and is entirely unconnected with the amnion of the Arthropoda. The latter is only analogous (and homomorphous) to the former, but not truly homologous (homophylous).

[1] The spinal marrow of the Vertebrata, and the ventral nervous cord of the Annulosa, are of course not analogous from this point of view, and these can just as little be compared as the sympathetic marginal cord of the former and the ventral nervous cord of the latter.

natural theory in its place, and without their having made any attempt to explain the origin of the Echinodermata. On the other hand, my theory, which fully explains its origin, has received the full sanction of two zoologists of the first rank upon whose judgment I lay the greatest weight, Gegenbaur and M. Sars (senior), the last recognised as one of the naturalists most thoroughly acquainted with the Echinodermata.[1]

The organs of sense of the different groups of animals are for the most part (perhaps entirely, with the exception of the skin as the organ of touch) not homologous; moreover, the homology is often not to be proved even within one of these groups, or is even positively negatived within a given class, as, for instance, in the organs of hearing of different insects. All point to these as of polyphyletic origin, and as having originated at different times from different portions of the upper germ-lamellæ. This manifoldly different and independent origin of the organs of sense is also very well conceivable phylogenetically.

The primordial kidneys have probably also originated from the upper germ-lamellæ, and these organs are probably homologous in all the Bilateria (in all the members of the five higher animal groups). The simplest form would be represented by the so-called "excretory organs" or "water-vascular system" of the Plathelminthes, which are originally nothing more than strongly developed tube-shaped dermal glands (like the sweat-glands). Comparative anatomy will perhaps later be in a position to prove that these primary kidneys of the unarticulated Plathelminthes, which reappear in each metamer of the articulated Vermes as so-called looped canals or segmental organs, have given rise both to the kidneys of the Mollusca and to the primary kidneys of the Vertebrata.[2] Gegenbaur has already proved the homo-

[1] The origin of the central nervous system from the original outer layer of the body of the animal, the horny layer, is one of the most striking examples of the value of the phylogenetic view, and its signification for the comprehension of the ontogenetic process. Hitherto this origination of the "internal" nervous system from the outer germ-lamellæ has been almost universally considered wonderful and paradoxical. But as soon as the problem is thus stated: "How can the nervous system generally have originated at first (phyletically)?" only the one answer, after ripe reflection, will be given to it: "From the most superficial parts of the body, which were constantly in communication with the outer world." Only from this constant communication could the first "sensation" develop itself. The nervous system has then withdrawn itself secondarily into the protected interior of the body, "separated from the horny layer." I do not consider the idea of a special "nervous layer," which many embryologists separate from the cuticular sensitive layer, to be confirmed.

[2] In Amphioxus the broad canal discovered by von Rathke, and more fully

logy of the "shell-glands" of the lower Crustacea among the Arthropoda (and the "green glands" of the Decapoda) with the primary kidneys of the Vermes. The Tracheata have quite lost this excretory organ, and the Malpighian tubes of the intestinal canal have taken its place. If we regard the primary kidneys as originally (phylogenetically) in this manner separated skin-glands, it also explains their originally superficial position in the vertebrate embryo. They are here undoubtedly derived from the upper germ-lamellæ, either directly from the horny layer or indirectly from cells of the "axial cord," which have passed from the horny layer into the dermal fibrous layer.

The dermal muscular layer, or the dermal fibrous layer (the "flesh-layer" of Baer, the dermal layers and primary vertebrate layers of Remak), is, as a whole, in its original simple commencement, probably homologous in all the six branches of the Metazoa, or certainly, at least, in the five phylæ of the Bilateria. It has probably originated in the Vermes, as well as in the Zoophyta (Hydra, &c.), from the upper germ-lamellæ, and has been inherited from the Vermes by the four higher groups of animals. The corium and the muscular dermal sheath are to be regarded as the two earliest products of its subdivision; both are perhaps of the same origin, and therefore homologous within the five higher phylæ (the Bilateria). The muscles of the trunk of the Vertebrata also proceed from this layer.

On the other hand, the skeleton system in the different groups of animals is not homologous. Both the internal skeleton formations of the Zoophytes, as well as those of the Echinodermata and the Vertebrata, are entirely different formations, peculiar to each phylon, although all three appear to originate from the dermal fibrous layer.

The external skeleton of the Vermes and Arthropoda, which is only a chitinised differentiation of the epidermis (the so-called hypodermis or chitinogen membrane), as well as the calcareous shells of the Mollusca (also exudations from

described by J. Müller, which runs on each side in the folds of the skin of the ventral surface (immediately at the outer surface of the sexual glands), and which opens externally behind on both sides of the *Porus abdominalis*, is perhaps to be considered as a homologue, or as a rudiment of the original primary kidneys. (A second further opening in the mouth-cavity is problematical.) If the comparison of this dermal canal of Amphioxus (fig. 40, Pl. I, of J. Müller's work) with the primary kidneys of the Vertebrata, and with the similar excretory organs of the Vermes, were correct, this would establish a very interesting connection between the two latter sets of organs, and would at the same time explain the origin of the passage of the primary kidneys in the Vertebrata from the outer germ lamella.

the epidermis), do not come under consideration here at all.

The cœlom or the body-cavity, the original "pleuro-peritoneal cavity," which is entirely absent in the Protozoa, Zoophyta and Acœlomi (Plathelminthes), is certainly homologous in the Cœlomata, and in the four higher stem-groups of animals. It originates everywhere as a slit between the two muscular layers, and has apparently descended from the Cœlomati, the worms with blood, to the four higher groups of animals. However, this homology is not to be established by comparison with the cavity of segmentation, from which Kowalevsky makes the cœlom proceed (comp. above, p. 165). The cœlom is originally filled with a fluid, which, on account of its varying characters, can be defined as hæmolymph or hæmochyle. But in the higher worms this nutritive fluid is already differentiated into two different constituents, into the colourless chyle or lymph which fills the body-cavity, and into the coloured blood, which circulates in the closed vascular system. This differentiation also recurs in the Vertebrata.

The intestinal muscular layer, or the intestinal fibrous layer (the "vascular layer" of Baer, the intestinal fibrous layer and middle layer of Remak), appears to be entirely absent in part of the class Zoophyta (in the sponges and the lowest Acalephæ), and to develop itself in a peculiar form in another part (in the higher Acalephæ).

In the Acœlomi it already begins to shape itself out as the "intestinal muscular sheath," and has descended from these to the higher worms (the Cœlomati), and from the latter to the four higher stem-groups of animals. There is nothing in the way of our recognising a universal homology in this within these five groups of animals (the Bilateria).

The vascular system, which, as a whole, has developed itself in connection with the cœlom, is, therefore, also to be compared within the five higher stem-groups of animals; but the question as to how far its separate parts, and especially the heart, are homologous, is very difficult to decide. According to the sharp-sighted comparison of Gegenbaur, the heart of the Arthropoda and Mollusca is originally homologous to a section of the dorsal main vascular stem of the Vermes, while the heart of the Ascidia and Vertebrata is homologous to a section of the ventral stem.

The intestinal glandular layer, which remains constant as the epithelial outer covering of the intestinal canal and its glandular appendages, is certainly, throughout the whole animal kingdom (only excepting the Protozoa), from the

sponges to the vertebrata, everywhere homologous, and everywhere is derived directly from the entoderm of the gastrula. To be sure, Kowalevsky has lately arrived at the opinion that the intestinal glandular layer of insects forms an exception, and is much rather to be regarded as a special new formation *sui generis* ('Embryologische Studien an Würmern,' 1871, p. 58). This view seems to me untenable. If any organ can be homologous in all six phyla of the Metazoa, it is certainly the intestinal canal, with its outer covering epithelium, the intestinal glandular layer. On the other hand, the question of the homology of the openings of the intestine, the mouth, and anus, is at present still quite obscure, and so much only is certain that the opening of the mouth is not always the same. The original oral opening of the gastrula, the rudimentary mouth or the Prostoma, seems only to have descended to the Zoophyta, and, perhaps, to a part of the Vermes. It, nevertheless, seems to reappear in the Rusconian anus of the Vertebrata. On the other hand, the oral openings of the Vertebrata, the Arthropoda, and the Echinodermata, are peculiar new formations, and certainly not homologous with the rudimentary mouth.

7. The Phylogenetic Signification of the Ontogenetic Succession of the Systems of Organs.

The regularly graduated series in which the system of organs appear one after another in the different groups of animals during ontogenesis, furnishes us with a sure key, according to the biogenetic principle, to the historical series in which the animal systems of organs have developed themselves after each other and from each other, during the long and slow course of the organic history of the earth. This palæontological seniority of the systems of organs, as it is empirically found *à posteriori* from the facts of ontogenesis, completely anticipates on the whole the demonstrations which could be formed on the subject *à priori* by physiological reflection and by philosophical consideration of forces at work (Causal-Momente).

In the first place, it follows from the comparison of the gastrula, and of the bilamellar cell-condition which represents it in the most dissimilar groups of animals, that two primary systems of organs, the inner intestinal system, and the outer tegumentary system, are simultaneously differentiated in the first series, in the oldest Metazoa, the Gastraeada. The original and perfectly simple stomachic cavity or primary intestine of the Gastraea is, indeed, the oldest organ of the

body of the Metazoa; but, simultaneously with its origin, has proceeded the separating of the two cell-layers of its wall, the inner nourishing epithelia (the gastral lamellæ or entoderm), and the outer investing epithelia (the dermal lamellæ or exoderm).

In the second line of succession the elements of the skeleton-system (in the majority of the Metazoa?) formed themselves, and this in the layer of the exoderm, as the sponges teach us. Although in the sponges the two primordial germ-lamellæ have (universally?) remained constant in their original simplicity, and no third germ-lamella has developed itself from them, yet in the thickened exoderm of many of them we find present a very complicated and extensively differentiated skeleton-system. Indeed, already the Protozoa have very generally formed skeleton-parts both for protection and support. It is unnecessary to mention in addition that the skeleton-system in the different groups of animals is of different epochs and of phylogenetic origin.

In the third line of succession the nervous and muscular systems develop themselves simultaneously. The beautiful investigations of Kleinenberg on the ontogenesis of Hydra[1] have informed us of the simultaneous origin of these two systems of organs which here exist in the most intimate reciprocity. The highly interesting neuro-muscular system of the Hydra is placed immediately before our eyes in *statu nascenti*. The neuro-muscular cells developed from the exoderm of the Hydra show us the functions of both still united in a single individual of the first order. The two systems of organs first appear independent and opposed to each other, through a separation and a division of labour into nerve-cells and muscle-cells. True muscles, in the strictest sense of the term, therefore, occur first in those animals in which true nerves also appear, and *vice versâ*. As the Acalephæ show us, only the dermal or parietal neuro-muscular system has originated at first from the outer germ-lamellæ. The gastral or visceral neuro-muscular system (intestinal muscles and nerves) has probably originated independently in a perfectly analogous manner from the intestinal glandular lamellæ. Hitherto nothing has been said against the view that the visceral nervous system has arisen independently of the parietal; the former is just as much in connection with the intestinal muscular layer as the latter with the dermal muscular layer.

In the fourth line of succession the kidney or excretory

[1] An account of these investigations is given by Prof. Allman in the January number of this Journal.—Ed.

system has developed itself, the physiological signification of which to the animal organism in general is greater than that of the younger blood-vascular system and the cœlom which is connected with it. This opinion is confirmed by the Plathelminthes, which still possess no cœlom and blood-system, but perhaps possess rudimentary kidneys (excretory canals), and also by their universal occurrence throughout the whole animal series, and, lastly, especially by the early appearance of the "primary kidneys" in the embryo. All which shows that we have here to do with a very old and important arrangement of organization, which already existed in the Acœlomi before the formation of the blood-system and the cœlom, and has descended from thence to the higher groups of animals.

In the fifth line of succession the blood-vascular system and the cœlom developed themselves first after the kidney system. We have already shown that these two parts stand in inseparable connection, and that the true body-cavity or the cœlom is to be considered as precisely the first commencement of the vascular system. After the commencement of the development of the intestinal fibrous layer, by its detachment from the adherent dermal fibrous layer, a cavity is first formed between these two muscular layers, which fills with the chyle which has transuded through the intestinal wall. This was the cœlom in its simplest form, and this hæmochylic-system or primordial primitive blood-system has subsequently become differentiated into two different systems of fluids, into the lymph-system and the true blood-system.[1]

In the sixth line of succession the genital system has first developed itself morphologically as an independent system of organs (!) Certainly this has already been physiologically present the longest of all, before any other system of organs became differentiated. We certainly already meet with single cells scattered in the endoderm of the intestinal tube in the sponges, some of which develop into germ-cells, and others into sperm-cells; and this was probably already the case in the Gastraeada. Only in all

[1] A very different view of the cœlom and of the blood-system, as well as of the kidney-system, has been developed by E. R. Lankester in his oft-quoted article ('Annals and Magazine of Natural History,' May, 1873). He regards these two systems of organs as identical, and thinks that the "excretory organs or water-vessels" of the Acœlomi form the first commencement of a body-cavity, and that this cœlom is therefore opened externally from the beginning. On the contrary, my opinion is that the cœlom is primarily closed, and originated subsequently to and independently of the older primary kidney-system. The connection of the two would then be secondary. The ontogenesis of the Bilateria seems to me to contradict E. R. Lankester's opinion.

the Zoophyta does the formation of both kinds of sexual cells from the epithelium remain confined to certain parts of the gastro-canal system; and even in many worms there are still no independent persistent sexual organs present in a morphological sense. In many worms (Bryozoa, Annelida, &c.) individual cœlom-cells, scattered cells of the "pleuro-peritoneal epithelia," develop themselves periodically into sexual cells. An independent differentiation of special sexual organs seems, therefore, to occur later, perhaps at different times in the different groups of animals. The decision of this very difficult question is, in general, connected with the problem of the homology of the sexual organs, and with the primary phyletic origin of the sexual cells, one of the most difficult problems of ontogenesis and phylogenesis. I would in addition here to the observations which I have made on this subject in the 'Biology of Calcareous Sponges' (pp. 469, 471), wish to hint as to the possibility of both primary germ-lamellæ sharing in the formation of sexual cells. For, although in most cases the origin of the sexual cells from cells of the intestinal fibrous layer, or even of the primary gastral layer, is proved, yet in other cases they appear to originate just as certainly from the dermal muscular layer, or even from the primary dermal layer (Hydra).

On account of the positiveness with which opposite views concerning the origin of the sexual cells are maintained even within the single group of Zoophyta, it may finally still be suggested whether a translocation of them has not occurred so early (already within the Laurentian period) that their apparently original conditions may now, indeed, be their second home. I have proved that in the calcareous sponges the egg-cells which originally arise in the endoderm often pass very early into the exoderm by their amœboid movements, and there continue their growth. In many Calcispongiæ the egg-cells are much easier to be found in the exoderm (their secondary place of abode) than in the endoderm (their primary original position), so that I even believed at one time that they arose originally in the former. We may now, perhaps, venture to suppose that this early transport of the cells from one primary cell-layer to the other, by continued "shortened or contracted inheritance," in the course of generations, would be continually thrown further back in ontogenesis, till it finally takes place already during the differentiation of similar furrowed cells into the two forms of cells of the two primary germ-lamellæ. Then the cells which originally (phylogenetically) belonged to the inner germ-lamellæ nevertheless

(ontogenetically) apparently occur first in the outer germ-lamellæ, and *vice versâ*. I suspect that this is often actually the case in the sexual cells, and that, generally, such an early transport of the cells has played a significant part through the change of place and change from one germ-lamellæ to the other becoming constant by inheritance. This transport also possesses great significance for our above-stated view of the original difference of the two muscular layers, and may, for instance, explain much in the early axial concrescence, in the blending of the germ-lamella in the axial cord of the Vertebrata, as well as in their later divergence.

8. The Significance of the Gastraea-Theory for the Theory of Type.

If one judges the above-given confirmation of the Gastraea-theory as sufficient, and acknowledges the conclusions drawn therefrom as on the whole right, one will then have arrived at the conviction that as a consequence the so-called type-theory—which to this very time is in general looked on as the profoundest basis for a zoological system—has been abolished, at least so far as its present significance goes, and an essentially different classification of the animal kingdom put in its place. As is known, this highly renowned and highly meritorious theory of types, which in the second decennium of our century two of the most important contemporary zoologists attained to by different ways, culminated in the idea that in the animal kingdom many fundamentally different principal groups are to be discerned; for each of which peculiar "types" there is a quite characteristically immanent and persistent "plan of structure." This plan of structure is determined through the peculiar position and connection of the constitutive organs, and is entirely independent of the grade of perfection and development traversed by the various classes of animals of each type within its sphere. Both George Cuvier, who, by the path of comparative anatomy, and Carl Ernst Baer, who, alone and independently of Cuvier, arrived at this idea by the path of comparative ontogenesis distinguished in the whole animal kingdom but four such types, which Baer, according to the different manner of ontogenesis, characterised in the following manner :—(1) Radiata, with a radial development (*evolutio radiata*); (2) Mollusca, with a contorted development (*evolutio contorta*); (3) Articulata, with a symmetrical development (*evolutio gemina*); (4) Vertebrata, with a double symmetrical development (*evolutio bigemina*). Cuvier, as

also Baer, took each type for something absolutely persistent, and, in spite of all modifications, in the deepest sense unalterable ; consequently here they allowed no connection of any sort and no transition between the four different types. Baer, besides, insists that the type of the lowest forms of each of the four groups must be pronounced as well defined as in the highest, and that, consequently, the type of development is entirely independent of the grade of improvement.

In contrast with the earlier prevailing erroneous opinion that the whole of the animal kingdom represented a single uninterrupted gradual scale of beings, and that a single continuous succession of development proceeded from the lowest of the Infusoria through the different classes up to Man himself, the light which the type-theory threw over the different portions of zoology, but particularly over comparative anatomy and over the history of development, procured for it a speedy entrance into the zoological system, and the four types were soon pretty commonly looked upon as the basis of very exact scientific system of animals. One was, indeed, soon compelled, through the advance in one's knowledge of the lower animals, to pull to pieces that very unnatural type Radiata. First, Siebold in 1845 separated from it the Protozoa, and at the same time he divided the Articulata into Arthropoda and Vermes. Leuckart, in 1848, was the first to distinguish as two distinct types the Cœlenterata and Echinodermata. So, from the original four types arose the seven diverse main groups, which to this day are still also in vogue in most systems equally as the highest and most general of the chief divisions of the animal kingdom. But the peculiar essence and the original signification of the theory of types was not touched by the augmentation of the number of types. The aims of the later zoologists was much more directed to defining by the same standard the four new types (Protozoa, Cœlenterata, Echinodermata, and Vermes), and combining each of these as an isolated form entity, with the peculiar "plan of structure," in which was the basis of arrangement for the three retained older types (Arthropoda, Mollusca, Vertebrata) of Baer and Cuvier. The idea, ever since then, growing stronger of the entirely independent character and the immanent "structure plan" of these seven types of animals is to this day still generally prevalent; so that, for example, Claus, even in the newest edition of his 'Zoology' (1872, p. 41), points out the type-theory as the most important advance in science since Aristotle, and as the very foundation of the natural symptom systems. Even Hopkins names the types, moreover, "the Kepler's laws

of the animal kingdom," and sees in them, with Keferstein and others, the "most brilliant confutation of the Darwinian heresy," and the strongest argument against the truth of the theory of descent.

This last point our adversaries have themselves, without foreseeing it, pointed out as the Achilles' heel of the theory of types. For it is quite certain that the theory of types, in the original sense of its authors, does, without doubt, stand in a fundamental contradiction to the theory of descent. This contradiction lies not so much in this that the types are considered as completely independent and separate higher groups of the animal kingdom, but rather in the teleogical principal of their conception. The idea that the types form entirely independent groups of forms is of course inconsistent with any monophyletic conception of the animal kingdom, which traces all animals as descendants from a single common root-form; but it would allow itself to be brought into unison with the theory of descent in this that one requires for each type an independent stem-form, consequently the entire animal kingdom requires a polyphyletic descent—so many types, so many phyla. The conception of the immanent original "plan of structure of the types," which forms the true teleogical ground principle of the theory of types, is, on the contrary, perfectly inconsistent with the theory of descent.

As soon, therefore, as the theory of descent reformed by Darwin attacked the Baer-Cuvier theory of types, it compelled the latter to defend itself by, first, freely giving up its teleogical ground principle, and, secondly, at the same time, the connection of the types with one another had to be modified. The first attempt towards this I made in 1866 in my 'General History of Development' ("General Morphology," 2nd volume, chapters xvi, xix, xxiv, and xxv). First, I have there already pointed out that Baer's type of development is nothing further than the consequence of inheritance, and Baer's grade of improvement is nothing further than the consequence of adaptability (l. c., p. 11); therewith, on the one side, the dualistic notion of types or the teleogical plan of structure is brought back to the mechanical principle of inheritance (consequently to the physiological function of increase), l. c., p. 171; on the other hand, the dualistic idea of perfection or the teleogical aim of increase is consequently reduced to the mechanical principle of adaptability, that is, to the physiological function of nutrition (l. c., p. 193). Secondly, I have, then, already shown that the different higher types of the animal kingdom can be only

conceived in a genealogical sense as stems or phyla, but that the higher phyla of the animal kingdom (Vertebrata, Mollusca, Arthropoda, Echinodermata) are to be considered as diverging descendants from the lower stems of the Vermes, which have taken their origin from diverse branches of this numerous lower animal group; and that, lastly, the Vermes and the Cœlenterata must have started off from those still lower groups of organisms, the Protozoa or Protista (l. c., pp. 413, 414). I have more definitively expressed this opinion in the first edition of my 'Naturliche Schöpfungsgeschichte' (1868), and in the succeeding editions I have sought to state it more clearly. I failed in evolving it into perfect clearness, because the Gastraea-theory, to which I first of all was led by my 'Monograph of Calcareous Sponges,' was not yet formed. It was only by means of the Gastraea-theory and its consequences that the phylogenetic relationship of the types of animals to one another was completely cleared up.

It might be asserted that the Gastraea-theory is only a reform or modification of the theory of types, because three of the primitive four types (Vertebrata, Mollusca, and Arthropoda) have been retained nearly within the original limits of their conception, but the content of this conception has become completely different. Besides, moreover, between the two theories there is this most essential difference, that in the "type-theory" the types appear as co-ordinate, self-existing groups of forms of equal morphological value, alongside each other, and yet independent one of another; whereas in the "Gastraea-theory" the phyla exist as partly co-ordinate, partly subordinate, groups of completely different morphological value; partly near, partly alongside each other, but all in a common connection.

In the excellent explanation which Gegenbaur has given in the second edition of his 'Grundzüge der vergleichenden Anatomie' (1872, p. 72) of the animal types, these various references of types of different value to one another have been clearly explained, and, through the most sagacious investigation of details, has been further strongly built on the sure foundation of comparative anatomy. Gegenbaur shows that the seven types or phyla have their limits sometimes tolerably distinctly fixed, and sometimes are by no means to be distinguished from one another; that one must distinguish between the lower and higher types, and that the different higher types or phyla disclose in their common point of departure the lower. Through this demonstrable connection of the phyla it will appear that the whole of the members of the animal kingdom can be placed in a near

alliance, whereby the ground is got ready for a monophyletic system. Through these cognisable connections the hard and fast conception of the stems, as derived from the earlier doctrines of type, must become significantly more pliant, for we find the relationship of the types to one another in the manner as we meet the subdivisions within the types, *i. e.*, in genealogical partition (l. c., p. 77).

With this conception the type-theory of Baer and Cuvier is at once destroyed, as well in the extent as in the content of the idea of type. The type has consequently completely lost its earlier significance, and so far as it is a category of the system, possesses no other philosophical significance than the lowest category of class, order, genus, species, and so forth, it is now only relatively (through its height), not absolutely, distinguished from the latter ; so even Gegenbaur, from the line of comparative anatomy, has attained to the same position in respect to the type-theory as that to which the way of comparative ontogenesis has carried us. The type-theory has an extraordinary merit for zoology, and, as the highest principle of the classification of the animal kingdom, had effected on all sides an uncommonly fruitful and stimulating work. Its efficaciousness is, however, to be looked on now as ended. The consistent application and carrying out of the theory of descent which we have compared with it is no longer sufficient; in its place must now come the phylogenetic classification of the animal kingdom, the essential basis of which is formed by our Gastraea-theory.

APPENDIX.—Synoptic Phylogenetic Tables.

For a hasty survey of the general results which appear to develop themselves from the Gastraea-theory, the following four phylogenetic tables are appended. To avoid the many misinterpretations which I have put on the similar tables and stem-structures in my 'General Morphology' and in my 'Natural Creation,' as also in my 'Monograph of Calcareous Sponges,' I may here expressly mention that these claim absolutely no dogmatic currency, that they are merely essays to give a clear insight, with the help of the Gastraea-theory, into the important relationships of the ontogenetic and the phylogenetic development of animals and their primary system of organs. Should the attempt not be agreed with, let some better positive be put in its place, but let the objector not rest contented, as too often happens, with a mere negative rejection. At all events, the herein proposed system of animals coincide closer to the impoitant facts of developmental history than all other hitherto attempted experiments of classification.

I.—*Table of the Phylogenetical Development of the System of Organs of Vertebrata founded on the Gastraea-Theory and the Ontogenetic Comparison of the Vertebrata with the Invertebrata.*

A. EXODERMA. External primitive Germ-lamella. ANIMAL GERM-LAMELLA. Dermal layer. LAMINA DERMALIS. Epiblast.	*a.* First Secondary Germ-lamella. NEURO-DERMAL LAYER (Dermal Layer, *Baer*), or NEUROBLAST (Lamella neurodermalis).	I. HORNY TUBE. *Tubus corneus.*	1. Epidermis (cuticle). 2. Epidermal appendages (hair, nails, feathers, &c.). 3. Epidermal glands (sweat-glands, sebaceous glands, &c.).
		II. NEURAL TUBE. *Tubus nerveus.*	4. Spinal Marrow. 5. Brain. 6. Sense organs (the greater part).
		III. SEXUAL TUBE. *Tubus urogenitalis.*	7. Primitive kidneys (?) (phylogenetically primitive epidermal glands). 8. Urogenital glands (?) (phylogenetically primitive exoderm-cells ?).
	b. Second Secondary Germ-lamella. FIBRO-DERMAL LAYER (Muscular Layer, *Baer*), or INOBLAST (Lamella inodermalis).	IV. CORIACEOUS TUBE. *Tubus coriaceus.*	9. Corium (skin and skin muscles).
		V. MUSCULAR TUBE. *Tubus carnosus.*	10. Hollow muscles. 11. Endoskeleton (chorda, vertebra, &c.). 12. Exocœlar (?) (parietal cœlom-epithelium).
B. ENTODERMA. Inner primitive Germ-lamella. VEGETATIVE GERM-LAMELLA. Intestinal layer. LAMINA GASTRALIS. Hypoblast.	*c.* Third Secondary Germ-lamella. INTESTINAL FIBROUS LAYER (Vascular Layer, *Baer*), or HÆMOBLAST (Lamella inogastralis).	VI. HÆMAL TUBE. *Tubus sanguineus.*	13. Hæmolymph (primitive blood—primordial hæmal liquid). 14. Endocœlar (?) (visceral cœlom-epithelium). 15. Principal vascular stems (lymph- and blood-stems, heart). 16. Vascular glands (lymphatics, spleen, &c.).
		VII. MESENTERIC TUBE. *Tubus mesentericus.*	17. Mesentery. 18. Intestinal muscles (and coverings).
	d. Fourth Secondary Germ-lamella. INTESTINAL GLANDULAR LAYER (Mucous layer, *Baer*), or MYKOBLAST (Lamella mykogastralis).	VIII. MUCOUS TUBE. *Tubus mucosus.*	19. Intestinal epithelium. 20. Intestinal glandular epithelium.

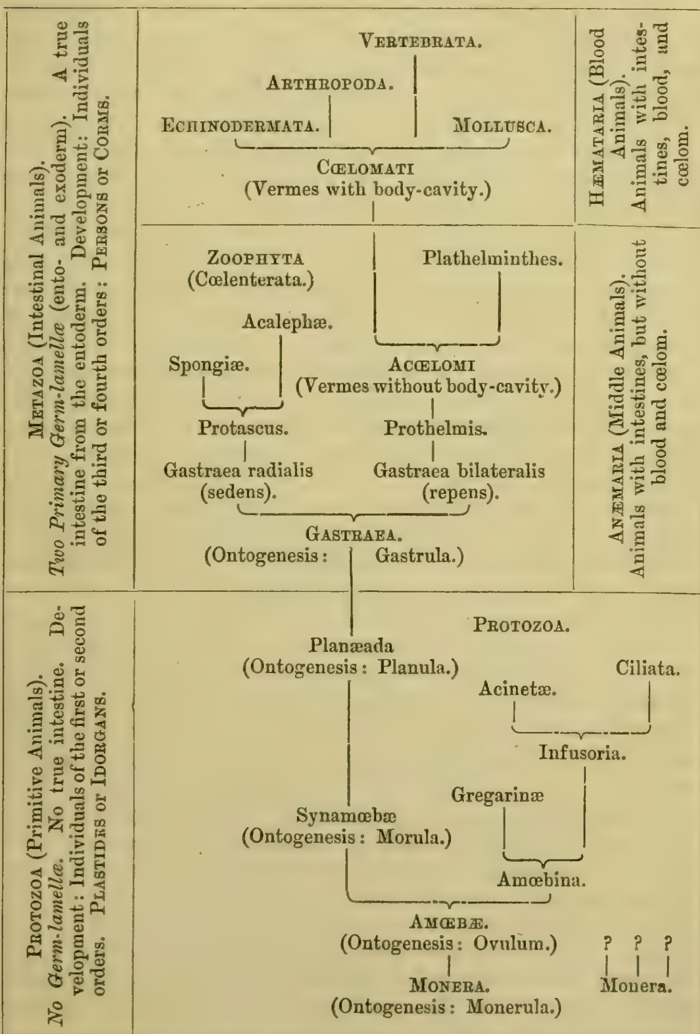
II.—*Synoptical Table of those Primitive Organs which, with probability, are considered as homologous in the Vermes, Articulata, Molluscous and Vertebrated Animals.*

VERMES.	ARTHROPODA.	MOLLUSCA.	VERTEBRATA.
I.—*Products differentiated from the Neuro-dermal Layer.*			
Epidermis.	Hypodermis (chitine membrane).	Epidermis.	Epidermis.
Primitive brain (upper œsophageal ganglia).	Brain (upper œsophageal ganglia).	Brain (upper œsophageal ganglia).	Marrow-bone or medullary tube (foremost part).
Organs of excretion ("water vascular, segmental organs").	Shell-glands of crustacea.	Kidneys.	Primitive kidney processes.
II.—*Products differentiated from the Fibro-dermal Layer.*			
Corium (and annular muscular sheath).	Corium (rudiment).	Corium and dermal muscles (First appearance!)	Corium and dermal muscles (First appearance!)
Straight muscular sheath.	Hollow muscles (longitudinal).	Inner hollow muscles.	Lateral hollow muscles.
III.—*Products differentiated from the Fibro-intestinal Layer.*			
Cœlom.	Body cavity.	Body cavity.	Pleuro-peritoneal cavity.
Principal dorsal vessels.	Heart.	Ventricles.	Aorta (primordialis).
Principal ventral vessels.	... ...	... ...	Heart (together with bulbus arteriosus).
Intestinal wall (exclusive of epithelium).	Intestinal wall (exclusive of epithelium).	Intestinal wall (exclusive of epithelium).	Fibro-intestinal layer and mesentery.
IV.—*Products differentiated from the Intestinal Glandular Layer.*			
Intestinal epithelium.	Intestinal hypodermis (for the most part).	Intestinal epithelium (for the most part).	Intestinal epithelium (excepting mouth and anus).

III.—*Sketch of a Phylogenetic Classification of the Animal Kingdom, founded on the Gastraea-Theory and the Homology of the Germ-lamellæ, the Primitive Intestine, and the Cælom.*

2 Sub-Regna.	3 Syntagmata.	8 Phyla.	16 Phylocladi.	40 Classes.
Protozoa (Subregnum primum).	First principal group of the Animal Kingdom: Protozoa. Primitive Animals, without Germ-lamellæ or Intestine, or Cœlom or Hæmolymph.	I. Protozoa.	1. Ovularia.	1. Monera.
				2. Amœbina.
				3. Gregarinæ.
			2. Infusoria.	4. Acinetæ.
				5. Ciliata.
Metazoa (Subregnum secundum): Descendants of Gastraea.	Second principal group of the Animal Kingdom: Anæmaria. Intermediate Animals (bloodless intestinal animals), with two primary Germ-lamellæ and Intestine, but without Cœlom and Hæmolymph.	II. Zoophyta (Cœlenterata).	3. Spongiæ.	6. Gastraeada.
				7. Porifera.
			4. Acalephæ.	8. Coralla.
				9. Hydromedusæ.
				10. Ctenophoræ.
		III. Acoelomi.	5. Acœlmio (Vermes I).	11. Archelminthes.
				12. Plathelminthes.
	Third principal group of the Animal Kingdom: Hæmataria. Blood Animals (blood-carrying intestinal animals), animals with two primary Germ-lamellæ, with Cœlom and Hæmolymph; all having at the same time a muscular and a nervous system.	IV. Cœlomati.	6. Cœlomati (Vermes II).	13. Nematelminthes.
				14. Polyzoa.
				15. Tunicata.
				16. Rhynchocœla.
				17. Gephyrea.
				18. Rotatoria.
				19. Annelida.
		V. Mollusca.	7. Brachiopoda.	20. Spirobranchia.
			8. Otocardia.	21. Lamellibranchia.
				22. Cochlides.
				23. Cephalopoda.
		VI. Echinodermata.	9. Colobrachia.	24. Asterida.
				25. Crinoida.
			10. Lipobrachia.	26. Echinida.
				27. Holothuriæ.
		VII. Arthropoda.	11. Carides.	28. Crustacea.
			12. Tracheata.	29. Arachnida.
				30. Myriapoda.
				31. Insecta.
		VIII. Vertebrata.	13. Acrania.	32. Leptocardia.
			14. Monorrhina.	33. Cyclostoma.
				34. Pisces.
			15. Anamnia.	35. Dipneusta.
				36. Halisauria.
				37. Amphibia.
			16. Amniota.	38. Reptilia.
				39. Aves.
				40. Mammalia.

IV.—*Monophyletic Stem-structure of the Animal Kingdom, founded on the Gastraea-Theory and the Homology of the Germ-lamellæ.*



On Arranging *and* Cataloguing Microscopic Specimens. By J. W. Groves, F.R.M.S., Hon. Sec. to the Medical Micro. Soc.

This subject seems to be one of some difficulty, from the fact that most authors who have written upon it, and most people who possess collections, follow different methods without being altogether satisfied with any of them; moreover, it is a question of importance, for upon the arrangement adopted, and the convenience of the catalogue, depends the space gained or wasted in the cabinet, and the comparative ease or difficulty of finding any given preparation.

Manifestly, the system to be recommended must depend upon whether the collection be large or small, and also whether miscellaneous or only of certain classes of specimens. For small collections I am inclined to advocate an absence of classification in the cabinet; because, if a small collection be miscellaneous—and it generally is—such arrangement would only involve a great waste of space, without the slightest advantage being derived therefrom, provided only such a catalogue be adopted as the one I am about to propose.

For large collections a systematic arrangement of the specimens becomes necessary, and also, I think, more systematic catalogues than such as are generally written.

In large collections—for instance, that in the Hunterian Museum of the Royal College of Surgeons (the arrangement of which is so well described by Dr. J. Murie in vols. I and VIII of the 'Monthly Microscopical Journal,' in his excellent article "On the Classification and Arrangement of Microscopic Objects")—I would have a separate catalogue for every series or subseries in the classification of the specimens, while for small collections one catalogue will generally suffice.

By the method ordinarily adopted, if one does not happen to know the slide required by its general appearance, it is necessary to examine several under the microscope, or at any rate to read the labels of several, before it is found, and consequently much loss of time is involved; whereas, by my method, which is of universal application and very simple, one has only to refer to the proper heading in the catalogue or index, and so to pick out the very preparation wanted without further trouble. Thus it is evident that my method is of extreme use to those who, like myself, frequently have to demonstrate certain points of structure to a class.

As my own collection is comparatively small, miscellaneous,

and yet required for special purposes, I will describe its arrangement, and the catalogues which I use with it.

My collection is divided into three parts, viz.—A, a general one for diatoms, plants, insects, minerals, &c.; and two special ones, B for normal, and C for pathological histological preparations.

Each of these divisions has a separate catalogue, and as each of these is drawn up in a precisely similar fashion, I will describe that for normal histological preparations, as it is the most complete.

It consists of a simple alphabeted note-book, in which is contained an alphabetical index to everything contained in every preparation, each reference being numbered according to the numbers on the slides. These are placed in the cabinet without any regard to arrangement, and simply numbered consecutively, thus—7, Auerbach's ganglia; 8, stomach of dog, showing gastric peptic glands; 9, voluntary muscle, &c. As the collection increases, and a new cabinet is required, the numbers are continued as though there were but one cabinet.

To show the method of entering in the catalogue the contents of each preparation, I will run over my specimens of small intestine.

Under the heading "I" is found:—

Intestine small, 106, 107, 108, 109, 117, 120, 209, &c.
  Muscular coat, external trans. sect. 108.
    „ „ long. sect.
    „ internal trans. sect.
    „ „ long. sect., 108.
  Villi, 106, 107, 108, 117, 120, *149, 150, 162, 207, 208.
    „ epithelium of, 117, 209, *108.
    „ muscl. invol. of, *207, 149, 150.
    „ lacteals of.
    „ blood-vessels of, 120, *106, 107, 108.
    „ lymphatic tissue of, 207, 208, 149, 150.
  Peyer's patches, 109, 147, 148.
    „ „ columnar epithelial cap of, *209, 147.
  Peyer's patches, trabeculæ of, 147, 148.
    „ „ lymph-corpuscles of, 147, 148.
    „ „ vessels of, 109.
  Brunner's glands, 117.
    „ vessels of, 117.
  Lieberkuhn's glands, from surface.
    „ „ vert. sect., 106, 107, 108, 117.
    „ „ trans. sect.
    „ „ vessels of, 106, 108.
  Muscularis mucosæ, 207, 150, 107.
    Lieberkuhn's glands penetrating, 107.
    Brunner's glands „
    Peyer's „ „ 209.

Intestine, small—*continued.*
Mucous membrane.
,, ,, vert. sect.
,, ,, corp. cells of, 117.
Blood-vessels of, 106, 107, 108, 117, 109, 120.
Nerves of.

Then each of these components of the small intestine is entered again under its approximate heading, thus:—

Under "M"—
Muscle, involuntary of small intestine, vide intestine.
Muscularis mucosæ of small intestine, vide intestine.
Mucous membrane of small intestine, vide intestine.

Under "V"—
Villi of small intestine, vide intestine.

Under "L"—
Lymph-follicles of small intestine, vide intestine,

and so on.

It will be observed that some of the numbers are marked with a star (thus, *247). This denotes that those preparations show the part mentioned under the heading specially well, though the others also show it more or less perfectly. Thus—Peyer's glands, epithelial cap., 147, *209. Of these No. 209 is the best. Again, Villi, muscle in, *247, 149. Of these *247 shows it most perfectly.

The other divisions of my collection are treated in a precisely similar manner, and from what I have now said, it will be seen that, in a small collection, no space need be wasted, because the cabinets are gradually filled up, and when others become necessary the numbers simply follow on consecutively from the last slide in the cabinet just filled; while, at the same time, it will be evident that for small or large collections, and whether the slides contained in them be arranged systematically or not, there will not be, in either case, the slightest difficulty in finding any given slide in a moment.

I may add that it will be found handy to have a simple numerical list of slides, as well as that arranged alphabetically, because then if a preparation be mislaid, it will be easier to find out what it was, and thus to replace it, if the clue thus given do not enable it to be traced and found again.

In conclusion, let me add that it will be found to save time, and, what is of more consequence, the preparations will be preserved with less risk of injury if kept in cabinets which will take them horizontally, instead of "on edge." This remark applies with special force to all specimens put up in a fluid medium, no matter of what kind.

NOTE *on* "PICRO-CARMINATE *of* AMMONIA." By E. CRESSWELL BABER, M.B. Lond.

(Read before the Medical Microscopical Society, March 20, 1874.)

In this note I wish to draw attention to a microscopic staining fluid which, as far as I am aware, is very little, if at all, known or used in England. This fluid is the picro-carminate of ammonia, invented by M. Ranvier, and largely used in his laboratory at Paris.

M. Ranvier first described this fluid in 1870, but since that time he has made considerable changes in its method of preparation.

I propose to describe shortly the method of preparation and employment, the way in which it colours tissues, and, finally, to indicate some of its advantages over other staining fluids in use. The picro-carminate of ammonia is made by mixing—

Carmine (best)	1 gramme.
Liq. Ammoniæ	4 cubic centimet.
Water	200 grammes.

Add to the mixture five grammes of picric acid, and after agitating, decant, leaving the excess of picric acid. The decanted liquor is then left for several days in a bottle, being agitated from time to time. Then evaporate to dryness by exposure to the air in a shallow vessel. This takes two, three, or more weeks, according to the time of year. The red powder which has thus formed is then scraped from the bottom, and can be kept either in this form or as a liquid ready for immediate use. The liquid is made by simply dissolving the powder in water in the proportion of about two parts of powder to 100 of water, allowing it to stand for a few days and filtering. The filtering is best done through a *double* layer of filtering paper, as otherwise solid particles are apt to pass through. The liquid thus made ought to have a yellowish red appearance and ought not to smell of ammonia. To prevent the formation of fungi a few drops of a solution of carbolic acid must be added. The liquid can then be kept an indefinite time, requiring only occasional filtration.

The picro-carminate of ammonia not being a definite chemical compound, is sometimes troublesome to prepare, but the quantities mentioned in the above method appear to give as good results as any.[1] It is therefore always advisable

[1] For the above quantities, as well as for several other hints on Picro-Carmine, I am indebted to M. Malassez, Répétiteur at the Collége de France, Paris.

to test its goodness when emerging from the filter; this is done in the following manner:—Place a drop of the solution on to a piece of white filtering paper, and allow it to dry, when, if the picro-carminate be good, a yellow spot is formed surrounded by a distinct red ring.

Observers differ in the exact shade of yellow or red, which they prefer, but if, with the fluid prepared as above, the two colours be distinctly marked, and the solution sufficiently concentrated, there can be no doubt about its goodness. If the picric acid be in excess the yellow colour will preponderate over the red, and *vice versâ.* Should the solution be too dilute, as indicated by the colours being very faint, it may be strengthened by concentration, by the digestion in it of more of the desiccated powder, or by repeated filtration through the same filter, by which latter method more of the picro-carminate is taken up by the water each time.

In order to be sure of having the right proportion of the ingredients to start with, it is as well to apply this test also to the mixture *before drying,* as *after desiccation the relative proportion of the picric acid, carmine, and ammonia cannot be altered without evaporating to dryness again.*

Specimens can be put from water into the staining fluid, but from this, if the full coloration of the picro-carminate is required, they must be put *directly into glycerine,* for, if placed first in water, the picric-acid is dissolved out. If, on the other hand, the staining by *carmine only* is desired, the preparation is passed through water before being put in glycerine, and it is said that the colouring thus obtained is more regularly disposed than that obtained by ordinary carmine.

As the picric acid does not fix itself to the tissues like the carmine, in order that the yellow colour that it produces be permanent, it is necessary to add a small quantity of picro-carminate to the glycerine in which the specimen is preserved.

The following method of staining and mounting is convenient:—The section is placed on a glass slide and a drop of the colouring fluid dropped on it; after a few minutes, when the specimen is seen to be sufficiently stained, the cover glass is put on, and some of the following mixture drawn under by means of filtering paper—

Solution of Picro-Carminate . . .	1 drop.
Glycerine	10 drops.
Water	10 drops.

The specimen can then be sealed up. The exact propor-

tion of the picro-carmine contained in the glycerine is not of much consequence, provided there is an excess of picric acid present. The colours of specimens mounted in this way improve very much for some time after they are put up.

Specimens hardened in chromic acid or Müller's fluid, likewise those which have been kept long in osmic acid, do not stain so easily as others. The picro-carminate of ammonia stains the tissues in several colours, varying from a bright red to an intense yellow. It colours *yellow* the horny layer of the epidermis, the central cells in the bird's nests of epithelioma, hairs, nails, cartilage (very slightly), and elastic fibres; nuclei of cells are coloured *bright red;* the fibres of connective tissue of a *rose colour;* the protoplasm of most cells takes a *reddish-yellow colour;* and, lastly, the red blood-corpuscles assume a *brown* tint.[1]

In the *epidermis*, for example, the picro-carminate distinguishes three layers:—

I. Most superficially the horny layer, consisting of flattened cells, coloured of an *intense yellow.*

II. An intermediate layer of cells filled with granules, which are coloured of a *bright red.*

III. And, lastly, a layer of cells under this coloured of a *dull yellow*, with their *nuclei* stained *red.*

These three layers can often be distinguished in the bird's nests of squamous epithelioma, the centre containing the intensely yellow cells, outside this is the red layer, and, most externally, the dull yellow cells with red nuclei. This indicates plainly the development of the epidermal cells inwards, passing through the three stages.

The great advantage the picro-carminate has over other staining fluids is its property of staining tissues in a series of colours varying from red to yellow; it has the minor advantages of colouring rapidly and equally, and of being able to be kept in the dried form.

I may mention that in Frey's 'Microscopic Technology' (4th German edition) picro-carminate of ammonia is alluded to in a few lines, but only the original method of preparation employed by M. Ranvier is given.

[1] These colours will vary *slightly*, according to the quality of the Picro-Carminate.

On DIATOMACEÆ *from* SPITZBERGEN. By the Rev. E. O'MEARA, A.M. With Pl. VIII.

THE collections which are the subject of the present paper were made by Rev. A. E. Eaton, who went out to the Arctic Sea in Mr. Leigh-Smith's yacht. They consisted, 1st, of some stones coated with mucor, in which no diatoms were found; 2nd, of several bottles of various size. Of these a large number had unhappily been broken in the conveyance and the contents lost except the material that remained attached to the surface of the glass. This material was carefully examined, but not a single diatomaceous frustule appeared to requite the labour, so that it may be inferred that no loss was sustained by the casualty. Of the bottles which came uninjured one was rich in forms, the others contributed only a few to the general result. 3rd, of a large package of a very miscellaneous nature, made up of broken shells, pieces of seaweed, sand, and such like; its general appearance was not encouraging, nevertheless it yielded forms of sufficient number, variety, and interest, amply to requite the labour of preparation.

Cleve and Lagerstedt have investigated the diatomaceæ of Spitzbergen, and favoured us with the result. The latter in his treatise, 'Sötvattens Diatomaceer fran Spetsbergen och Beeren Eiland,' confined to the fresh-water forms of the district; the former in his 'Diatomaceer fran Spetsbergen,' 16th Dec., 1867, published in the 'Öfversigt af Kongl. Vetenskaps Akad. Förhandlingar,' Stockholm, 1868, and also in a more recent publication in English, 'On Diatoms from the Arctic Sea,' Stockholm, 1873, in which frequent reference is made to forms from Spitzbergen.

The gatherings placed in my hands, so far as those are concerned in which diatoms occurred, were exclusively marine, so that I could pursue the track only of Professor Cleve, and that only in respect to the marine forms described by him in the two treatises referred to; and, considering the limited nature of the available material, with most satisfactory results.

Cleve calculates the number of diatomaceous species hitherto discovered within the entire range of the Arctic Sea at 181. These Spitzbergen gatherings of Rev. Mr. Eaton yielded no less than 92; of these the following have been noted by Professor Cleve:

Achnanthidium arcticum,* Cleve.
Amphiprora nitzschioides,* Cleve.
„ *longa*,* Cleve.
Amphora granulata, Greg.
„ *cymbifera*, Greg.
„ *lanceolata*,† Cleve.
„ *proteus*, Greg.
Biddulphia aurita, Lyng.
Campylodiscus angularis, Greg.
Cocconeis costata, Greg., = *C. pacifica*, Grun., = *C. Archeri*, O'M.
„ *decipiens*,* Cleve.
„ *scutellum*, Ehr.
Coscinodiscus radiatus, Ehr.
„ *oculus iridis*, Ehr.
„ *excentricus*, Ehr.
„ *subtilis*, Ehr.
Grammatophora macilenta, W. Sm. = *G. oceanica*, var. *macilenta*, Grun.
„ *arctica*,* Cleve.
Navicula arctica,* Cleve.
„ *Bombus*, Ehr.
„ *directa*, W. Sm.
„ *æstiva*, Donk.
„ *fusca*, Greg.
„ *Lyra*, Ehr.
„ *pinnularia*,† Cleve.
„ *pygmæa*, Kütz.
„ *Smithii*, Bréb.
Nitzschia angularis, W. Sm.
„ *constricta*, Kütz.
„ *distans*, Greg.
„ *macilenta*, Greg.
„ *socialis*, Greg.
Rhabdonema arcuatum, Lyngb.
„ *Torellii*,* Cleve.
Pleurosignia angulatum, W. Sm.
„ *delicatulum*, W. Sm.
„ *intermedium*, W. Sm.
„ *naviculaceum*, Bréb.
„ *longum*,* Cleve.
Stauroneis pulchella = *St. aspera*, Cleve, *Navicula aspera*, Ehr. and Donk.
Synedra Kamscatica, Grun.
„ *thalassothrix*,* Cleve.
„ *superba*, Kütz.

Surirella fastuosa, W. Sm. = *Novilla fastuosa*, Cleve.
Systephania anglica, Donk., possibly = * *Thalossosira Nordenskioldii*, Cleve.

Those marked with an asterisk are new forms described by Cleve in his work 'On Diatoms from the Arctic Sea,' to which those interested on the subject are referred for further information. I may be permitted, however, to make a few remarks concerning two of them, namely, *Amphiprora longa* and *Navicula* (*Amphiprora ?*) *arctica*—the author is doubtful to which genus the latter-named species belongs.

Amphiprora longa seems to me to bear a very strong resemblance to *Amphiprora lepidoptera*, Greg. ('Diatomaceæ of the Clyde,' Pl. xii, fig. 59); so much so that I should be almost disposed to consider it identical with that species.

Of *Navicula arctica* I have found, as I suppose, some few specimens; at least, they so closely resemble in shape and general character of the striation that figured by Cleve under that name that I would consider them scarcely distinct, although there is this difference between them, that, while in Cleve's form the inner band curves inward towards the central nodule, in my specimens the same band bends nearly parallel with the curvature of the external margin of the frustule, as shown in Pl. VIII, fig. 1.

The species thus marked † in the above list, namely, *Grammatophora arctica*, *Amphora lanceolata*, and *Navicula pinnularia*, are very distinct and beautiful forms, described and figured in papers of Cleve written in Swedish, and therefore unavailable to the generality of English students; I therefore take the liberty of figuring them, and the rather, as I wish to supply some additional particulars concerning them.

Grammatophora arctica, Cleve, "Diatomaceer fran Spetsbergen," 'Öfversigt af Kongl. Vetenskaps Akad. Forhandlingar,' Stockholm, 1868, p. 664, Taf. xxiii, fig. 1, is of very frequent occurrence, as are also the other two forms just noticed. Cleve's figure of the side view presents no appearance of striation; in some of my specimens the striæ are moniliform, as in Pl. VIII, fig. 2 *b*.

Amphora lanceolata, Cleve, 'Diatomaceer fran Spetsbergen,' Taf. xxiii, fig. 2, is described as having persistent costæ, only becoming very faint as they approach the median line; in the very many specimens which came under my notice the median line is more strongly developed than in Cleve's figure, and a considerable portion of the valve in its proximity is quite free from striæ, as shown in Pl. VIII, fig. 3. These specimens from Spitzbergen agree in all respects with some of the same species found by me many years ago in a

gathering from Jamaica, a fact which shows how independent these forms are of climatial influences.

Navicula pinnularia, Cleve, "Om Svenska och Norska Diatomaceer," 'Öfversigt af Kongl. Vetenskaps-Akad. Förhandlingar,' Stockholm, 1868, p. 224, Taf. iv, figs. 1 and 2. Of this species I found in the gatherings under consideration two well-marked varieties, one just as figured by Cleve, the other a much narrower form, and with finer striæ, which I have given in fig. 4.

Concerning the forms in the preceding catalogue I have further to remark that *Synedra Kamscatica*, Grun., 'Die Osterreichischen Diatomaceen,' p. 404, Tab. viii, fig. 6, is of very frequent occurrence, but the valve, instead of being bowed as Grunow figures it, is invariably straight. It is also much larger, but in all other respects identical. In the middle of the valve, where the striæ fail, there is a slight thickening of the margin on either side, and this feature is observable in the F as well as in the S V. (Pl. VIII, fig. 5.)

This species is at first view liable to be confounded with *Synedra tabulata*, but it is more slender, the striæ very much finer, and the middle of the valve is destitute of striæ.

In addition to the forms included in the foregoing list several species occurred already described, but not included in Cleve's enumeration of Diatoms from the Arctic Sea, viz.:

Amphora crassa, Greg.
,, *costata*, Greg., not W. Sm.
,, *lævis*, Greg.
,, *robusta*,* Greg.
,, *lyrata*, Greg.
,, *proboscidea*,* Greg.
Amphiprora alata,* Kütz.
,, *costata*, O'M.
Cocconeis arraniensis, Grev.
,, *binotata*, Grun. = *C. scutellum*, var. *Roper.*
,, *coronata*, Brightw.
,, *distans*, Greg.
,, *fimbriata*, Ehr.
,, *major*, Greg.
,, *nitida*,* Greg.
,, *ornata*,* Greg.
,, *pseudomarginata*,* Greg.
,, *splendida*,* Greg.
Coscinodiscus lineatus, Ehr.
,, *radiolatus*, Ehr.
Donkinia compacta, Ralfs.
Epithemia constricta, W. Sm.

*Grammatophora marina,** Kütz.
" *maxima,* Grun.
" *serpentina,** Ralfs.
Navicula Crabro, Ehr.
" *elegans,* W. Sm.
" *pusilla,* W. Sm.
" *rhombica,* Greg.
" *scopulorum,* Kütz.
" *didyma,* Ehr.
" " var. γ, Greg.
Nitzschia bilobata, W. Sm.
" *lanceolata,** W. Sm.
" *parvula,* W. Sm.
" *perpusilla,* Grun.
Pleurosigma strigosum, W. Sm.
Podocystis adriatica = *Surirella adriatica,* Kütz.
*Podosira hormoides,** Kütz.
Synedra nitzschioides, Grun.

Concerning *Podocystis adriatica,* Grunow, 'Die Osterreichischen Diatomaceen,' p. 467, observes that this species had not come under his notice from either the North Sea or the Atlantic Ocean. Many years since I found it in abundance on a specimen of *Grinnellia Americana,* gathered from the Atlantic Ocean in the vicinity of New York, and now I have found it in these gatherings from Spitzbergen.

In a note to his work 'On the Diatoms of the Arctic Sea' Professor Cleve alludes to a paper of mine published in the 'Journal of the Royal Dublin Society,' July, 1860, containing a list of diatoms found by me in gatherings made in the Arctic Sea by Sir Leopold McClintock, and mentions that thirty-seven of the forms included in my catalogue had not occurred in any of his samples from that region. It is with much gratification, therefore, I have to notice that eleven of these, viz. those marked with an asterisk, have occurred in these gatherings of Rev. Mr. Eaton, and, for the most part, in such numbers as to leave little doubt of their being indigenous.

Cocconeis binotata, C. coronata, and *C. fimbriata,* seem almost cosmopolitan forms. I have found them in collections from various parts of the Indian Ocean, not unfrequently on the West Coast of Ireland, and now also in the neighbourhood of Spitzbergen.

The specimens of *Navicula didyma,* var. γ, Greg. ('Journ. Micr. Sc.,' vol. iv, Pl. v), fig. 16, were of very frequent occurrence. I cannot but think this form is entitled to rank as a distinct species. The space about the median line expands

on both sides so as to include a somewhat rhomboid area, very different, indeed, from the outline of this same space in *Navicula didyma*. This peculiarity appears in the specimens I have obtained in various parts of Ireland, as also in all the very numerous forms that came under observation while examining these collections from Spitzbergen. In addition to this striking peculiarity, the character of the striæ differs from that of *N. didyma*, being greatly coarser than they are in that species. I would suggest that the form should be named *Navicula Gregoriana*.

Over and above the forms included in the two foregoing lists the following came under notice, which appear to me not to have been hitherto described:

Asterionella Cleviana, n. s., Pl. VIII, fig. 6.—Length of valve ·0036; the lower end small and roundish; the upper end much larger and somewhat rhomboid in its outline; striæ marginal, costate. Several specimens of this occurred, always single, as might have been expected, so that I am not quite certain that I have assigned the form to its proper genus.

Amphora Eatoniana, n. s., Pl. VIII, fig. 7.—Length of valve ·0056; breadth ·0010; ends not produced; broadly rounded; dorsal margin strongly arched; ventral margin slightly expanded; expansion rounded; median line strongly marked, inclining inwards in an angle at the central nodule, and gently curved towards the dorsal margin at either side. Three longitudinal lines divide the valve into four compartments on the dorsal side of the median line. The two nearest to the median line, like it, are doubly arched, and in the same direction, except that they bend downwards at the middle towards the central nodule. The third line is gently arched nearly in the direction of the dorsal margin, and anastomoses with the second some distance from the ends of the latter. The striæ are finely costate, and appear on all the valve except the portion included between the second and third longitudinal lines. There are also two small unstriated spaces included between the ends of the first and second longitudinal lines. This is a very beautiful and peculiar form, to which, with much gratification, I give the name of the gatherer, Rev. A. E. Eaton.

Amphora Leighsmithiana, n. s., Pl. VIII, fig. 8.—Length of valve ·0058; breadth ·0008; dorsal margin slightly arched, nearly linear in the middle; ventral margin nearly linear, slightly incurved at the middle; ends attenuated; median line strongly developed, slightly arched towards the dorsal margin; central nodule small, but well defined. Striæ

strongly costate, distant. This form at first view might be confounded with *Amphora cymbifera*, but the costæ in that species are very much finer and closer than in the present.

Navicula Archeriana, n. s., Pl. VIII, fig. 9.—Valve constricted; length ·0036; greatest breadth ·0012; breadth at constrictor ·0008. Striæ marginal costate, parallel in the middle, slightly radiate towards the apices. A longitudinal line on either side of the median line divides the inner portion of the valve into three compartments without striæ. This form had been previously found by me in Ireland, namely, in gatherings by Professor E. Perceval Wright at the Arran Islands, and also in the stomachs of Ascidians from the Coasts of Clare, as well as in stomachs of Ascidians collected in Roundstone Bay, Co. Galway, by A. G. More, Esq.

Navicula nebulosa, var., Pl. VIII, fig. 10.—Valve elliptical; length ·0032; breadth ·0015. Marginal striæ obviously costate, not of uniform length as in *Navicula nebulosa*, Greg., but short in the middle and parallel, gradually lengthening towards the apices, and again becoming shorter as they approach the apices. Median line well defined, slightly enlarged towards the central nodule; on either side of median line and close to it there is a faint longitudinal line; between this latter and the marginal band of costate striæ the valve is marked with fine moniliform striæ radiately arranged. In *Nav. nebulosa*, with good illumination, similar striæ may be detected, but they are parallel, and extending not more than half way between the marginal band of striæ and the median line. A row of strong, short costæ extends along the longitudinal lines from the apices about one quarter the length of the valve; near the apices they are short, gradually increase in length, and then diminish till they vanish. Although this form in its main features so strongly resembles *Navicula nebulosa* that it could scarcely be considered distinct from it, yet the peculiarities I have noticed are such as are worthy of special attention.

Synedra arctica, n. s., Pl. VIII, fig. 11.—Valve expanded at the middle and ends; length ·0052; striæ marginal, finely costate. The valve on front view is linear, with a slight expansion at the ends; striæ marginal. This peculiar and well-marked form occurred with tolerable frequency.

I have only to add that some specimens were found of a form which at first I was disposed to consider new, but which, upon more mature consideration, I think, is not unlikely identical with *Navicula Auklandica*, Grun. I was unable to obtain a front view, so cannot say whether the striæ on the connective membrane noted by Grunow in *N. Auklandica*

were present or not. Although on the side view the form, as figured by Grunow, differs from mine, still, in most respects, the form under consideration corresponds with Grunow's description, "Ueber einige neue und ungenügend bekannte Arten und Gattungen von Diatomaceen,' 'Verhandl. der K. K. Zool. Bot. Gesel. Wien.,' Band xiii, 1863, p. 151, Taf. v, fig. 14. In Grunow's figure the outline sufficiently resembles that of mine, Pl. VIII, fig. 12, but the median line is straight; in mine it is doubly arched. The striæ are of uniform length throughout, slightly radiate, not reaching the median line, but forming a tolerably broad longitudinal space in the middle of the valve. In my form the striæ run up to the median line, except at the middle, where they form a tolerably large free space round the central nodule. They are parallel, rounded off towards the margin.

On Clavopora hystricis—*a* New Polyzoon *belonging to the* Family Halcyonelleæ. By G. Busk, F.R.S., F.R.M.S. With Pl. IX.

The curious form here described was procured during the expedition of the Porcupine in the Mediterranean from deep water off the African coast, and was kindly submitted to me for examination by Dr. Carpenter.

From the inspection of a single specimen it is, of course, difficult to determine whether or not it represents the mature growth of the species, or may not be regarded as a young and growing bud. I am, however, inclined to think that it is full grown, from the circumstance that the substance appears to be completely differentiated into definite polypides and tissues. Amongst the latter the muscular seems to me to present such a remarkable peculiarity that even on that account alone it is worth while to place a brief notice of the animal on record.

The growth is about one eighth of an inch in height, and in the form of a club, with an expanded subglobular head, and it appears to have been affixed to some foreign base by short radical fibres. The stem or peduncle is constituted of a cellular tissue, not unlike that of plants. In each cell may be observed several fibres crossing it for the most part in a

direction parallel with the longitudinal axis of the stem. These fibres, in many, if not in most, of which an elongated nucleus may be perceived at about the middle of its length, are attached at either end by a slight expansion. Here and there one may be perceived bifurcated, but for the most part they are undivided. In general character they bear so close a resemblance to one form of involuntary muscular tissue that it can scarcely, perhaps, be doubted that they are contractile in function, and, consequently, that by their agency the *Clavopora* is capable to bending its stem in various directions.

The club-shaped upper extremity, as well as can be made out in the spirit specimen, consists of cells similar to those of which the peduncle is constituted, and containing like them the same peculiar contractile fibres. The cells, however, in this portion of the polyzoary are more expanded, and in several of them (fig. 3 *a*) may be distinctly perceived the body of a polypide in the contracted condition, and proceeding from it elongated, slender, nucleated fibres, representing the retractor muscles. I have been unable to determine with any certainty the number of tentacles with which the polypide is furnished, but should estimate it at from twelve to fourteen. The outer wall of the cellular space or zooœcium presents an infundibuliform depression, marking the point at which the polypide was protruded.

From the characters above given I have little hesitation in referring the genus to the family of the *Halcyonelleæ*, with the following diagnosis:

Class.—POLYZOA.

Order.—CTENOSTOMATA.

Fam.—*Halcyonelleæ*.

Gen.—*Clavopora*, Bk.

Zoarium, simple claviform, subcapitulate, composed of distinct cells, traversed by nucleated (probably contractile) fibres.

Sp.—*C. Hystricis*. The only species.

Hab.—Mediterranean; Carpenter.

On the Etiology *of* Madura-foot; Note *by the* Rev. M. J. Berkeley, M.A., F.L.S.

[The following article appeared in the 'Indian Medical Gazette' of April 1, 1874. The Rev. M. J. Berkeley has favoured us with a reply to the objections which it raises to the hitherto received theory of the cause of the Madura-foot. —Eds.]

Whilst perusing a particularly able essay in a recent number of the 'Medico-Chirurgical Review' on the "Causes of Epidemics,"—an essay which we heartily commend to such of our readers as have not seen it,—we were not a little surprised to observe that a writer who, whilst manifesting such discrimination as was evident on every page of this Review, should nevertheless have cited "Madura-foot" disease as an example of "lesions *indubitably* dependent on extraneous vegetable growths."

We were surprised because we were aware that numerous carefully conducted experiments had recently been made in this country, with a view of definitely ascertaining whether any evidence of special "vegetable growths" could be detected in connection with this malady. The results of these experiments were of an entirely negative character.

We are not unmindful of the lessons conveyed by the numerous instances on record of vain attempts at verifying statements regarding the existence of parasites where their presence has been established beyond doubt; nor of the fact that probably seven-tenths of the profession regard the etiology of "Madura-foot" as satisfactorily demonstrated. Still, the evidence elicited by these experiments was so strong as to convince us that some serious mistake had been made before any such views could have been propounded.

We have recently received a pamphlet on the subject from the author, Dr. H. Vandyke Carter,[1] but, after careful study of its contents, have not been able to alter our opinion in the slightest degree. This pamphlet and its accompanying plate may, we presume, be taken as an epitome of the author's previous writings and drawings in connection with this malady, doubtless embodying also the experience gained during the dozen years or so which have transpired since his views were first placed before the profession.

[1] "The Parasitic Fungus of Mycetoma," by H. Vandyke Carter, M.D., 'Transactions Pathological Society of London.' 1872-73.

These views are so well known that it is scarcely necessary to refer to them at any great length. Suffice it to say that Dr. Carter believes that he has shown that the disease is caused by a distinct fungus—a peculiar red mould, which has not been seen except in connection with Madura-foot. This mould was first observed by Dr. Vandyke Carter in May, 1861, "upon part of a diseased foot which had been placed in water for maceration.......The next occasion of its occurrence was during the following year, in the month of April, in connection with a specimen of Mycetoma preserved in spirits; and again, also about the same date, the mould was seen on some rice paste in which some fresh black fungus particles had been placed, in order to ascertain if they could be made to grow artificially."

It will be observed that the mould referred to as having developed under these varying conditions was identified as one and the same kind of fungus—a fact which, *per se,* contains a sufficient refutation of the whole theory; for it is a physical impossibility that spores of fungi which had been preserved in spirits should retain their vitality, consequently the mould which grew on the spirit-preserved specimen *must have been of extraneous origin;* not only must it have germinated after the evaporation of the alcohol, but it must have originated from some source other than the interstices of the macerated tissue. We are, therefore, compelled to infer that the red mould, of various shades, described as having spread over portions of these three and other Madura-foot specimens, was but some developmental form of our ordinary pink-tinted moulds—bearing no relation whatever to the black, yellow, or orange-coloured particles frequently found in diseased tissues of this nature—no closer relationship, in fact, than a crop of various tinted mould on the surface of rice paste does to any coloured particles which may chance to be in its substance.

No mould with which we are acquainted, however, presents the slightest resemblance to the pink-coloured objects figured in the plate, purporting to represent "the structure of the red mould found in connection with Mycetoma (*Chionyphe Carteri*)"—figures, by the way, differing materially from those appended to the original text in the 'Bombay Transactions,' or any others which we have seen elsewhere, and which, we presume, must be considered as representing the *Chionyphe Carteri* more accurately than the early figures. So long as the forms here delineated are associated in the mind with the idea of *moulds,* one is certainly puzzled to account for their presence; fortunately, however, a sentence

in the descriptive text, attached to the plate, supplies us with a key: the objects depicted are referred to as representing "a fragment of the new growth as this appeared upon a specimen of the foot disease placed in water to macerate," and a very good representation it is of "fragments" which may very frequently be obtained in some specimens of tank water in which, however, no diseased foot need necessarily have been macerated.

Looking at the drawing, without reference to the text, we should describe the objects as being, probably, some confervoid growths, and the "spore-capsule," filled with pink-coloured globules, as the encysted gonidium of some Alga, not very unlike the gonidia of Pandorina, as figured in late editions of the 'Micrographic Dictionary,' or Pritchard's 'Infusoria.' To the Alga articles and plates of either of these volumes, or, better still, to some neighbouring tank at certain seasons of the year, we refer our readers for further explanation concerning the objects figured in this plate.

It is with much regret that we write in this manner concerning any of the labours of so industrious and accomplished an observer as Dr. Carter is known to be, but, when we find a doctrine, which we believe to be altogether erroneous—the result of a misinterpretation of microscopic appearances—used by men of eminence (who themselves may not have the opportunity, or possess the special training, necessary for this particular branch of study) as a basis upon which to found the etiology of other diseases, we feel that the time has arrived for giving free expression to our opinion regarding it.

Note by the Rev. M. J. Berkeley.

It must be presumed that the writer in the 'Indian Medical Gazette,' who has attacked Dr. Carter with reference to the fungous origin of the formidable disease known as the Fungus-foot of India, is not acquainted with the botanical articles on the subject in the 'Intellectual Observer' for November, 1862, or more especially in the 'Journal of the Linnean Society,' vol. viii, p. 139, even supposing that he had an intimate knowledge of fungi, or he could not at once condemn Dr. Carter for considering *Chionyphe Carteri* as a fungus rather than an alga. I must, however, take the whole responsibility on myself, as I consider myself justified after a most careful consideration of the subject, in confirming Dr. Carter's views. I have given in detail an account of the points of resemblance between the *Chionyphe* and certain *Saprolegniæ*, and the reasons which induce me to consider

these curious plants as related to *Mucorini*, amongst which they are less anomalous than they would be amongst algæ. The very fact alone of the *Chionyphe* being capable of cultivation on rice paste is almost sufficient to show what its real affinities are, for with the exception of *Chroolepus*, which is a very doubtful alga, no alga could be so completely a creature of air. Though several undoubted algæ (without eliminating such as are believed to be conditions of lichens) are not immersed, they flourish only in situations where there is an abundant supply of moisture. But allowing as little as possible for this consideration, no instance, as far as I am aware, has been recorded of the possibility of cultivating algæ on rice paste, the paste draining off its superfluous moisture, and no fresh fluid being added. I have no information as to the point whether the specimens transmitted to me from India were raised from samples which had been immersed in alcohol. They were perfectly dry when they came to me, and fragments of the large sclerotioid nuclei, when placed on the paste, at once communicated to it a red tint. I know of no observations which show that the spores of fungi would certainly be killed by alcohol, and I should not be surprised to find that they survived immersion. There is, however, no reason to assert that the specimens sent to me had ever been immersed in alcohol. In conclusion, I would observe that there is no other reason to suppose that the *Chionyphe* has any relation to algæ, except so far as it is related to *Saprolegniæ;* and those persons who have paid the closest attention to fungi, and have at the same time made algæ an especial object of study, are for the most part of one opinion as to the affinities of these curious aquatic organisms.

An Asexual Growth *from the* Prothallus *of* Pteris Cretica. By William G. Farlow, M.D., Harvard University. (With Plates X and XI.)

While studying the development of the archegonium in the *Polypodiaceæ,* in the botanical laboratory of the University of Strassburg, a peculiarity was first noticed in the prothallus of *Pteris cretica* which seems to have an important bearing on the question of the fern prothallus in general.

The material used was taken from a pot in which *Pteris*

cretica and *Aspidium molle* had been sown. At the beginning of the investigation there were a number of seedlings of both the above-named species which were considerably advanced in growth; and in addition there were numerous prothalli, from some of which young plants had begun to grow, and others still younger on which no incipient plantlets could be discovered with the naked eye. A search was made among the latter for prothalli in a condition suitable to demonstrate the earliest stages of growth after the fertilisation of the archegonium. Some of these prothalli were normally developed, having both antheridia and archegonia, from which occasionally an embryonal growth was seen. During the search, however, numerous specimens were found presenting the anomaly of scalariform ducts in the substance of the prothallus; and such prothalli, when still further developed, showed that the young fern-plantlets produced by them were the result of a direct budding of the cells, and not of the changes caused by the act of fertilisation in a single embryonal cell. The number of cases in which the above-mentioned peculiarity was manifested was about fifty; but, undoubtedly, the actual number was greater, inasmuch as some of the young fern-plantlets in the pot, which were too old to allow one to say whether they had been regularly developed (that is, by growth from an embryo) or not, probably belonged to the number of those developed by direct budding. The shape of the prothalli was, as usual, more or less obcordate; and those in which the anomaly presented itself, although variable in outline, were narrower than the others. This narrowness may have been only accidental and the result of crowding in the pot, as very often happens in the cultivation of ferns. In a single case one side was developed into a sort of secondary prothallus. The cells of the prothalli were perhaps somewhat paler than usual; and those which, near the concavity of the heart, are generally more numerous than in other portions and isodiametrical, were here much longer than broad,—that is, longer in the direction from the centre of the prothallus towards the concavity. As is well known, fern prothalli are generally heart or kidney-shaped, and the two sides composed of a single layer of polygonal cells, the centre of a portion decidedly thicker and consisting of several layers, which we may call the cushion; and in this last-named portion are situated the archegonia, while the antheridia, are much more widely dispersed, being found also in the lateral lobes. As before said, the most striking feature of the abnormal prothalli was the presence of a scalariform duct in the cushion a short distance back of the

concavity, just where the archegonia are generally found. But wherever such scalariform vessels were present there were no traces whatever of archegonia to be found, although antheridia were always abundant, as well as the hairs, which here fulfil the offices of roots. (See Pl. X, figs. 1 and 2, in which *a* shows the position of the scalariform ducts.) As may be seen from figs. 6 and 9, the scalariform ducts arise singly, and are situated in the central portion of the tissue of the prothallus. They scarcely differ in shape at first from the adjoining cells, which are longer and relatively narrower than the superficial cells. The ducts increase by division in a direction parallel to the surface, so that, in a longitudinal section, we find several lying one above the other.

Another peculiarity often, but not always, accompanying the presence of scalariform ducts, was the formation of a process or outgrowth in the concavity of the thallus, as shown in Pl. X, figs. 1 and 2. This outgrowth was variable in length, often being short and imbedded between the lateral lobes, but sometimes projecting as a narrow tapering process. In one case, it was forked at the extremity. The growth by means of a single terminal cell is shown in Pl. XI, fig. 9. As just mentioned, the existence of a process in the concavity is a striking peculiarity, but not quite a constant occurrence, like the presence of scalariform ducts. The first scalariform duct arises in the prothallus, as I have just remarked; and others soon appear, always in a line between the original duct and the nearest point of the concavity. In this way arises an interrupted row of ducts, which may extend, when a process is present, nearly to its extremity. The cells surrounding the original duct soon assume the form of ducts themselves, and thus a rudimentary bundle is formed. It happens rarely that two such scalariform ducts appear simultaneously in parts of the prothallus remote from one another. I only saw one such case.

It now becomes necessary to consider the relation of the scalariform ducts to the other cells of the prothallus, and this must be done by making longitudinal and transverse sections of the region in which the ducts lie. From such longitudinal sections (Pl. X, figs. 6 and 9), we see that the prothallus forms a compact tissue in which certain cells have assumed the character of scalariform ducts, while the others remain unchanged. From no section made was I able to see any trace of an archegonium. In two instances, when seen from above, a combination of four cells led me to suppose that there was some signification to be attached to this arrangement. But as a longitudinal section (Pl. X, fig. 7), shows no connection

between the four surface cells (two of which are seen at *z*) and the scalariform ducts, I am compelled to regard the two cases as having only accidentally such a superficial cell-conformation.

So far the changes mentioned have taken place in the plane of the prothallus itself. Now a change occurs which produces a growth in a direction perpendicular to the prothallus, and this growth is easily distinguished from the usual embryo growth. A swelling is seen, generally on the under surface of the prothallus, shortly after the appearance of the scalariform duct. This swelling is situated on or very near the line connecting the original duct and the nearest point of the concavity. When there is a process, this swelling very often appears near its extremity, as in Pl. X, fig. 2, *b*. When two such swellings appear simultaneously, they are generally situated side by side. In all cases, there is seen behind the swelling the scalariform duct or ducts lying in the substance of the prothallus itself. It is impossible for me to say in which cells of the prothallus this swelling or outgrowth originates. Longitudinal sections show no change by which the cells of the outgrowing portion—which is, in this case, on the upper instead of the lower surface of the prothallus as is more commonly the case—can be distinguished from the cells which are to remain a portion of the prothallus. From the not unfrequent appearance of a bursting through the surface, it may perhaps be inferred that the superficial cells take no part in the growth. Certainly no particular mother-cell or cells seem to be the place of origin of the new growth, but it seems to be a direct continuation of the prothallus cells, and not a distinct organisation temporarily attached to it, as is the case with an embryo growth. This swelling, to which I have intentionally avoided giving the name of bud, develops and shows all the characteristics of a fern leaf, and is, in fact, not a stem, but a true leaf. When it arises on the under surface of the prothallus, this leaf grows forwards, curves round the border of the concavity, and raises itself into the air, as in Pl. X, fig. 4, *b*. When two such swellings occur by the side of one another, one generally grows from the upper, the other from the under surface of the prothallus, as in Pl. X, fig. 5. In the meanwhile, there appears on the base of the leaf, or on what is now so far differentiated that it is evidently the leaf-stalk, a bud, which very soon can, by means of the cell-cap on its end, be recognised as a root (fig. 4, *r*). This grows always in a direction the reverse of the leaf; that is, backwards away from the concavity. After the appear-

ance of the root, a bud appears on the base of the leaf-stalk, looking towards the concavity, and from this grows the stem (fig. 4, *s*). As a rule, the leaf is tolerably far advanced in its development before the root appears, and the root invariably precedes the stem-bud. The terms forward and backward with relation to the concavity of the prothallus are, of course, inapplicable when the young plantlet is formed at or near the end of a process of the character above described, when the leaf and root shoot out *ad libitum*. In all cases a vascular bundle traverses the leaf and root, and these are in connection with the vascular bundle of the prothallus.

If now we compare Pl. XI, fig. 10, with fig. 257, in Sachs's 'Lehrbuch der Botanik,' p. 346, which represents a longitudinal section of a prothallus and a normally developed embryo attached, we shall clearly see that the cases we have been discussing differ widely from the ordinary cases of embryonal growth. Fig. 10 represents a longitudinal section through the spot where a young plantlet, such as we have described, shoots out from the prothallus (*p*, *p*), *b* represents the leaf, *r* the root, and *s* the stem-bud, which was cut a little to one side of the median line. First, at a glance, the figure in Sachs's 'Lehrbuch' differs from fig. 10 in the fact that the young plant in the latter case is so intimately connected with the prothallus that one cannot decide where the one begins and the other ends; while, in the former, it is perfectly easy to trace the outline of the young fern. Secondly, we have in the former a structure known as the foot, *f*, by which the developing fern is separated from the prothallus—a structure to which we find no equivalent in fig. 10. Thirdly, the vascular bundle of the plantlet is in direct connection with vessels which lie wholly in the prothallus. Fourthly, the order of evolution is different in the two cases. In the one, the leaf arose first, as we saw, and was tolerably well developed before a root and afterwards a stem-bud made their appearance. In the other the root anticipates by far both the leaf and stem-bud in its development; and, in fact, the root and stem are not produced from the leaf-stalk, but (and this fact is not to be learned from the figure, but from the accompanying description in Sachs) by the subdivision of a single cell into four, one of which forms the foot.

So far as I know, a budding similar to that in the cases described is only mentioned by Wigand, 'Botanische Zeitung,' Feb. 16, 1849, and by him in language which, it must be confessed, is not a little obscure:—"Eine beachtenswerthe Erscheinung begegnete mir bei einigen Exemplaren, nämlich

eine *Sprossenbildung*, ungefähr an der Stelle des Lagers wo das beblätterte Pflänzchen angelegt wird, entspringen junge *Vorkeime* von derselben Gestalt, wie die Hauptvorkeime im jungen Zustande, mit dem verschmälerten Ende (dem Sporenende entsprechend), an dem Lager festsitzend, später sich loslösend und wie ein selbständiger Vorkeim sich verhaltend." From the above paragraph, it would be, perhaps, difficult to say whether Wigand had seen anything similar to our case. But, taken in connection with his Tafel 1, fig. 25, where a process in the concavity is clearly seen, it seems probable that he had seen a growth which did not proceed from a fertilized archegonium.[1]

The bearing of the facts already enumerated upon the question of the function of the fern-prothallus is very important. Since the publication by Leszcyc-Suminski, in 1848, of his observations concerning the sexuality of ferns, the prothallus has been regarded as an organ intermediary between the spore and the fully-developed plant, growing out of the former, and bearing sexual organs which by mutual co-operation produce the latter. It has been considered impossible for a spore to produce a fern-plant directly without the intervention of a sexual union.[2] But, from the cases we have been considering, it is evident that this process is not absolutely necessary, since we have seen that a young fern can be produced from the spore by a purely vegetative or budding process—a process as clearly unsexual as, for instance, the production of plantlets on the fronds of *Asplenium viviparum*. This fact is an unexpected one for those who constantly see unity and simplicity in nature. Although in by far the majority of cases the prothallus does bear archegonia whose embryos develop into ferns, the monstrosity, if so we please to call the present cases, having once been noticed, may of course be expected to occur at any time; and, now that the attention of botanists has been called to it, it may prove not to be rare. As, in the present instance, certain

[1] As far as I am aware, no similar cases are described in any of Hofmeister's writings; but, on the authority of Dr. Askenasy, of Heidelberg, an example of a similar prothallus was shown by Hofmeister, when professor at Heidelberg, to the students in his laboratory. At any rate, a fern prothallus containing one or more vessels was seen by him, and probably a scantiness of material prevented a further study of the subject.

[2] [Sachs remarks that, like the thalli of *Hepaticæ*, the prothalli of ferns develop adventitious branches from some of their marginal cells, and this takes place especially in *Osmunda*, where the adventitious shoots detach themselves, and so constitute a means of vegetative propagation. Apparently it is only the thallus that is produced in this way, and not, as in the present case, the asexual generation.—Ed.]

examples bore archegonia with embryonal outgrowth, and others only direct bud-development, it is of course interesting to know whether the young plantlets of the two kinds of origin exactly resemble one another in their after development. For this purpose, a number of specimens evidently belonging to the category of abnormal growths were transplanted into a pot where their growth could be watched. During a recent visit to Strassburg I examined the specimens which had already attained the height of five or six inches, and they were sufficiently well developed to make it evident that they were plants of *Pteris cretica,* not of *P. serrulata,* as had been at first supposed.

In conclusion, I would take this opportunity heartily to thank Professor De Bary of Strassburg for material and advice kindly afforded during the course of the foregoing investigations.

Torquatella typica; *a* New Type *of* Infusoria, allied *to the* Ciliata (with Plate XII, figs. 1—5). By E. Ray Lankester, M.A., Fellow and Lecturer of Exeter College, Oxford.

Two years ago, at Naples, I found and made sketches of a very curious little Infusorium, which is sufficiently remarkable to deserve record, though I have but few details of its structure to communicate, and only met with it in one "gathering." It occurred in connection with a mass of eggs of *Terebella* which I was keeping for the study of the development of that annelid. Other Infusoria—true ciliate heterotrichous forms—were abundant in the same vessel of sea water, feeding on such of the eggs as were in a decaying state. Some of these contained red masses which they had engulphed—detached fragments of the broken-down *Terebella* eggs. Others were busy in making their way through slits in the chorion of certain eggs, eager to enjoy the feast within, and some of the egg-shells contained two or three Infusoria hopelessly drifting round and round, having eaten all the semi-decayed egg-yelk and apparently unable to return by the slit which had admitted them—most unquestionable cases for the foundation of elaborate theories of "heterogenetic metamorphosis" on the part of rashly speculative nature-philosophers — but such as are well enough known to assiduous students of the minuter forms of life. Here and there, among

these swarming ciliate Infusoria, I observed the specimens drawn in Pl. XII, figs. 1—5. They were exceedingly active, and had to be examined both in the living condition and after their movements had been arrested by the administration of a trace of Osmic Acid, in order to ascertain definitely their characteristics. Though having the appearance and habit of a ciliate Infusorian, this form—for which I propose the name *Torquatella*—does not possess any cilia at all. The body is oblong, and has the same mobility as that exhibited by most of the Ciliata. At the anterior extremity is placed the mouth, overhung by a capitular prominence, or upper lip (*c c*), as is not unfrequent in the group. There is a definite cuticular membrane to the body-sac, but, contrary to what occurs in most ciliate Infusoria, this does not transmit any delicate processes of vibratile protoplasm. There is not even a ring of such cilia surrounding the oral region and capitular prominence, as in *Vorticellidæ*, but in its place a complete delicate bell-like prolongation of the body wall, which may well be compared to an Elizabethan frill or plicated collar. This large collar quite overhangs the cephalic region, and reaches in front of it. It is no mere cuticular expansion, but has protoplasmic characteristics, being continually in a state of vibration, alternately closing up and expanding with a twisting movement, and exhibiting the same rapidity and regularity in this movement as do a series of cilia in a similar position. In fact, the movements of this collar may be best understood by comparing them to the movement of a series of cilia united to one another along their length by delicate membrane. In figs. 1—3 the collar is seen in a quiescent condition, when it exhibits obliquely-directed folds. In figs. 4 and 5 it is seen at the other extremity of the stroke, that is to say, expanded.

The vibrating collar of *Torquatella* functions as an organ of locomotion, and also serves to bring food-particles into the region of the mouth. In fig. 4, a *Torquatella* is sketched as seen in active progression. Locomotion is effected in the anterior direction, and consequently the cup or collar becomes fully expanded, its active "beat" being probably downwards and backwards. When the beat is sufficiently vigorous, the motion produced tends to prevent the collar, in its passive recoil, from gathering up round the mouth. But when the stroke of the collar (comparable to the stroke of a cilium) is less powerful, the organism remains unchanged in position, and the collar recoils to its full extent after each beat, gathering itself in folds round the oral region. The tendency of this less violent movement will be to bring a series of waves

of water against the oral surface, and consequently occasional food-particles. The rounded masses seen in figs. 1 and 2 are of an intense blood-red colour, probably due to foreign food-matters. I did not make out, in the few specimens which came under my notice, nucleus or vacuoles; it is very possible that more ample opportunity of observation would have enabled me to do so.

There is no Infusorian described which exhibits the replacement of cilia by a vibrating collar. In this journal, in October, 1871, I described a curious minute parasite from the blood of the frog (*Undulina*), which seemed to be a mouthless parasitic Infusorian, comparable to *Opalina* (*O. naidos*), but having, in place of cilia, an undulating membrane in the form of a crest. I have since learned from Professor Leuckart's report that it has been long known, being the *Trypanosoma sanguinis* of Gruby. *Torquatella* is much more nearly allied to the normal Infusoria Ciliata than is the minute, possibly immature *Trypanosoma* of the frog. It is not parasitic, and has mouth and cephalic prominence, in the former of which characters it definitely indicates its affinities with the one group of unicellular organisms which is mouth-bearing—namely, the Ciliata—whilst in the latter it presents a special point of agreement with particular genera of Ciliata. If the possession of a mouth were taken as the family mark of the highest branch of the Homoblastica or Protozoa, we might class, under such a group of Stomatoda, the Ciliata (including some forms become astomatous by parasitism), the Calycata (represented by *Torquatella*), and the Flagellata (containing *Noctiluca* and *Peridinium*, and excluding forms referable to the Algæ).

On the HEART *of* APPENDICULARIA FURCATA *and the* DEVELOPMENT *of its* MUSCULAR FIBRES. By E. RAY LANKESTER, M.A., Fellow and Lecturer of Exeter College, Oxford. (With Plate XII, figs. 6—8.)

Appendicularia (*Fritillaria*) *furcata* of Gegenbaur occurs not uncommonly in the spring on the surface of the Bay of Naples. The drawings and observations which I made two years since relating to this species have, to a large extent, been anticipated by the very valuable work of M. Hermann Fol, who has described and figured in a lavish manner several

species of the genus. There are some points, as to the mode of communication between the exterior and the branchial region of the pharynx, in which I do not find my notes quite confirmed by M. Fol's observations, and I hope to look further into that subject during the present spring. But at this moment I may draw attention to a structure in *Appendicularia* which has not hitherto been noticed by any one who has observed these interesting forms, excepting in a note by myself in the 'Annals of Nat. History,' 1873. The matter to which I now allude is one of histological interest bearing more or less directly upon the nature of transversely-striped muscular fibre. It also has a wider embryological interest, for I shall point out that an organ so important—usually so complex—as the heart—is in Appendicularia formed by only two nucleated cells, and actively functions whilst consisting of no more than two ultimate units, corpuscles, or plastids. The figures 6, 7, 8, in Pl. XII, represent the heart of *A. furcata*, drawn whilst under observation with a Hartnack's 10, *à immersion,* the movement having been caused to cease and the structure rendered clearer by the action of a solution of Picric Acid allowed to flow under the covering glass which held the specimens.

The heart (fig. 6) is that of a smaller and less mature specimen than those to which the hearts represented in figs. 7 and 8 belong. It consists of two conical or pyramidal cells or nucleated corpuscles, each connected to the other along one edge of its broad base by fourteen delicate filaments. During life these filaments are kept in rapid vibration, corresponding in character to the movement of cilia, held fast at each end, rather than to any movement of muscular fibres with which we are familiar. The movement is so rapid that during life the separate fibrils cannot be seen, and the vibrating region connecting the two conical cells has the appearance of a membranous sac. I am not certain that there is not an excessively delicate membranous connection between the fibrils, but I failed to convince myself that there is. Even in this younger heart (fig. 6) some of the fibrils are seen to exhibit an alternation of light and dark bands, transversely disposed. In this transverse striation the fibrils of the adult heart exactly correspond with the fibrils of the muscular mass which runs parallel with the notochord in the flabelliform tail, which structure, as well as other histological details of Appendicularia, is most satisfactorily brought into clear definition and preserved for future study by the use of Picric Acid, as above described, followed by a similar introduction of the clarifying and pre-

servative medium, Glycerine. This latter fluid is caused to flow under the glass cover by means of absorption along one of its sides, produced by a piece of blotting paper.

In the hearts of mature full-grown *A. furcata* the structure is a little more complicated, as seen in figs. 7, 8. In fig. 7 the fibrillar part of the heart is obscured by the œsophagus which runs across this particular part, and has not been displaced in the slide from which the drawing has been made. Fig. 8 shows but one heart-cell, with its connected fibrils. There are thirteen fibrils in the former of these hearts, and twelve in the latter. The variation in their number can have no significance. In fig. 7 they are most clearly seen to arise from one edge only of the broad base of each heart-cell, and to leave the rest of the margin free. As an addition to what was observed in the smaller heart, there are now present small secondary corpuscles, lying at the base of the fibrils, sometimes between two, sometimes closely embracing two or three. These small secondary corpuscles (*s, s*) are not nucleated cells, and it is not easy to form an idea as to the mode of their origin. They are not indicated in the earlier condition of the heart, and it is clear that they are not the morphological equivalents of the two large conical heart-cells. One cannot be sure that the condition represented in figs. 7, 8 is the final, adult heart,—a strange reduction of that organ if it be so, since it has not even a tubular structure or cavity, still less are there vessels connected with it. It is simply a most vigorous churn, beating and stirring up the fluid in the great perivisceral hæmolymph space without propelling it in any particular direction.

The reduction of the *number* of the constituent cell-elements or plastid-units in such small organisms of elaborate organisation as are the Appendicularìæ and the Rotifera, may help to make clear some of the processes of growth and development in organisms generally. To what extent can this reduction be carried? May we not possibly even arrive at a stage in retrogressive metamorphosis where cells no longer differentiate at all? Are we not prone to assign too important an office to the plastid, even as an element in complexity of organisation? The living matter of the organism is what develops and elaborates structure; its segregation into a greater or less number of corpuscles is a simple effect of the relations of bulk and cohesion. At the same time the limits of size on the side of minuteness which can be presented by the higher types of organisms seem to be determined by the impossibility of reducing the number of constituent units

beyond a certain point. After this point the typical organisation itself is no longer maintained. The Rotifera are reduced to the smallest possible size compatible with their high organisation. The smallest exhibit loss of *organs* (*e. g.* the ciliated canals), and appear to be at the extreme point in reduction of the number of plastids, whilst *Appendicularia furcata* is in a similar condition among Notochordate Pharyngobranchiata.

REVIEW.

The Anatomy of the Lymphatic System. By E. Klein, M.D., Assistant-Professor at the Laboratory of the Brown Institution, London. Part I. *The Serous Membranes* (with ten plates). London: Smith and Elder. 1873.

This valuable memoir is doubtless one of the most important contributions made to histology within the past year. We are, however, relieved from the necessity of giving a very elaborate notice of the contents, since a portion of the work has already appeared in our journal ('Quar. Jour. Micro. Sci.,' 1872, p. 142).

It deals partly with the normal, partly with the pathological conditions. As regards the normal conditions the following summary is given by Dr. Klein :—" The attention of histologists has been chiefly, if not wholly, directed to three questions—(1) the distribution of the lymphatic vessels in the serous membranes; (2) the origin of the lymphatic capillaries from the lymph-canalicular system of Recklinghausen; and (3) the free communication between the lymphatic vessels and the serous cavity by means of stomata. The description refers to the minute structure of the omentum, the centrum tendineum of the diaphragm, and the pleura mediastini."

The first chapter treats of the endothelium of the free surface of the serous membranes. The most noticeable point here is the normal germination of endothelium observed by Dr. Klein in the peritoneum of guinea-pigs, cats, dogs, and monkeys. In the fenestrated portion of the omentum are seen on the surface of the trabeculæ " small groups of club-shaped or polyhedral granular cells, projecting from the surface of the trabeculæ like buds." These appearances are seen in healthy organs, though they become more abundant and strongly marked in acute or chronic inflammation.[1]

[1] Similar features in the human omentum were described in a paper

In the second chapter are discussed the cellular elements of the ground-substance or connective-tissue-corpuscles. These are described as flat branched cells lying parallel to the surface, and, as shown by Rollett, in the cornea, the lymph canalicular system corresponds to these cells. Spherical or lymphoid cells, of which all intermediate sizes exist, from a rounded nucleus with a thin zone of protoplasm up to those which are twice as large as a common colourless blood-corpuscle are seen in the lymph canalicular system. The origin of fatty tissue is illustrated partly by a description of a gelatinous body which lies in the infra-orbital fossa of young rabbits, and which is composed of rudimentary adipose tissue or mucous tissue.

It is not easy to give a condensed account of Dr. Klein's observations on the lymphatic vessels of the serous membranes, which form the subject of the third chapter. The essential points have, however, been already stated in this journal, in the article before referred to.

With regard to blood-vessels, Dr. Klein holds that new capillaries are formed from those previously existing both by the continuous excavation of the branched cells connected with their walls, and are also formed in an isolated manner in the branched cells themselves, becoming united ultimately with the existing capillaries. This method is similar to that first pointed out by Stricker in the new formation of blood-vessels in the tadpole and in inflammation, which was afterwards confirmed by Arnold.

We cannot here enter upon the pathological relations, but they illustrate in a surprising manner the normal anatomy of the parts, and supply fresh example, if any were needed, of the close connection of physiology with pathology.

We may also point out that many of these observations have more than a professional or pathological interest. The morbid changes of the cell-elements, which he describes and figures in great detail, are of the highest importance for the general question of the vital phenomena of protoplasm. Moreover, the full account, such as we now have, of the histology of the serous membranes of the peritoneal cavity, cannot but excite the attention of the comparative anatomist, who will not fail to recognise in many of the structures and processes of growth described the counterpart of pheno-

communicated to the Medical Microscopical Society in June of last year. See this Journal for 1873, p. 309; also 'British Medical Journal,' March 21st, 1874.

mena known to him among the invertebrate relatives of the Vertebrata, such as Annelida, Gephyrea, and Mollusca.

The work is illustrated by ten very beautiful plates, executed in Germany, the expense of producing which was borne by the Government Grant Committee of the Royal Society. The researches were conducted in the laboratory of the Brown Institution, under the management of the University of London. We are glad to see such valuable work appearing under the auspices of these learned bodies.

NOTES AND MEMORANDA.

Cement for Mounting Objects in Cells containing Fluid.—As I have found great convenience in the use of the material I am about to mention, I have thought others might find it equally convenient when they have occasion to enclose objects either microscopic or others in glass cells. The advantage it possesses arises chiefly from the circumstance that it can be used under water, or weak spirit, so that the cover can be affixed beneath the surface of the fluid; and thus the admission of air-bubbles can be effectually prevented. It has also the advantage of retaining its adhesive property for several days if requisite.

The preparation, which may be termed "caoutchouc size," is prepared by melting pieces of caoutchouc in an iron or porcelain cup until it is reduced to the condition of a very viscid tar. As this tar, however, in its primitive state is too viscid for use, it should be dissolved in benzine so as to form a fluid of the consistence of thick gold size.

When spread over the edges of the glass cell or vessel intended to contain the object, it should be allowed to dry for a quarter or half an hour, by which time the benzine will have evaporated, leaving the surface exceedingly sticky; and this stickiness is not impaired by immersion in water. Consequently, if the cell or vessel with its contents is wholly immersed, the cover may be applied and pressed firmly in its place while still under the surface of the fluid.

No other fastening is absolutely required, but it is better when the surfaces are dry to apply a solution of shellac or other varnish round the edge of the cover.—George Busk.

Mode of Staining Animal Tissues of a permanent Purple-grey Colour.—Having from time to time been very successful in staining some animal tissues of a rich transparent permanent purple-grey colour, it may be of use to some of your readers were they acquainted with the particulars of this staining process which is a very simple one, and are as follows:

Submerge the tissue to be stained, in the necessary quantity of an ordinary carmine-staining fluid, such as either Beale's or Rutherford's fluid, until it has become of a decided carmine tint; next drop into this fluid containing the preparation a little of Draper's[1] dichroic ink in the proportion of about four drops of the ink to each drachm of the carmine stain. Shake the containing vessel gently until the two fluids are thoroughly mixed.

The length of time the preparation should remain in this mixed fluid will depend upon its thickness, and will vary from six to twenty-four or to forty-eight hours.

When sufficiently coloured, remove the preparation from the fluid and wash carefully with either filtered or distilled water until it ceases to impart a tint to the water. It is then ready for mounting in Price's glycerine.

I believe that logwood is one of the ingredients of the ink, the true composition of which is a trade secret. Possibly ordinary logwood stain would answer the purpose as well as the ink, but of this I have no experience, having found the ink so efficacious.

I have some very beautiful preparations stained in the manner above mentioned and mounted in glycerine; of these organic muscle and delicate fasciæ are probably the most striking.—B. WILLS RICHARDSON, F.R.C.S.I.

Dr. Reyher on Synovial Membranes.—The memoir promised in our last number has been withdrawn by the author (whose name was printed by an error as Reijner), with a view to its earlier publication in Germany and this country.

Action of Fresh Cholera-Ejections upon Animals.—Högyes (*Centralblatt für die Medicinischen Wissenschaften*, Nos. 50 and 51) states the results of his experiments on the action of fresh cholera-ejections upon dogs and rabbits. The injections were employed one and one and a half hours after passing from the patient. The author has found—1. That fresh cholera-ejections act injuriously upon the animal organism, and, as it seems, on different animals in different degrees. 2. The chief, or at least most constant, phenomenon of the injurious action after every form of introduction of the cholera-injections, is a more or less strongly pronounced inflammatory change of the stomach and intestinal tract. 3. A catarrh of the stomach or intestine artificially produced renders the animal more susceptible of the injurious effect. 4. Inspiration of air saturated with particles from non-disinfected cholera-ejec-

[1] Mary Street, Dublin.

tions can produce the same symptoms as the immediate action in the stomach, rectum, or nervous system, whilst the particles of cholera-ejections disinfected by carbolic acid appear to be quite innoxious. 5. A current of air carries with it small particles from non-disinfected ejections with vegetate rapidly under favorable circumstances, whilst the fungi from cholera-ejections disinfected by carbolic acid are capable of propagation. 6. Cholera-ejections freed from form-elements can produce, by their chemical constituents, the same pathological effects as with their form-elements.—W. Stirling, D.Sc., M.B.—*Medical Record.*

Causes of Decay of Teeth.—These are not, according to Leber and Rottenstein, internal or vital so much as external and chemical. The process of decay begins from the surface, and if it can be controlled or arrested at the surface it is entirely controlled. The great causes of caries are two—viz., acids and fungus found abundantly in the mouth, *Leptothrix buccalis.* This latter agent is characterised by certain microscopic appearances and by its reaction with iodine and acids, which give to the elements of leptothri a beautiful violet tinge. Under the microscope the fungus appears as a grey, finely granular mass or matrix, with filaments delicate and stiff, which erect themselves above the surface of this granular substance so as to resemble an uneven turf. The fungus attains its greatest size in the interstices of the teeth. No one can deny nowadays the action of even weak acids in dissolving the salts of the enamel and the dentine, making the enamel, naturally transparent, first white, opaque, and milky, and, in a more advanced state, chalky, and the dentine more transparent and softer, so as to be cut with a knife. The acids which may actually effect the first changes in the production of caries are such as are taken with food, or in medicines, or such as are formed in the mouth itself by some abnormality in our secretions, which should be alkaline, or by an acid fermentation of particles of food. Acids play a primary part, making the teeth porous and soft. In this state, the tissues having lost their normal consistency, fungi penetrates both the canaliculi of the enamel and of the dentine, and by their proliferation produce softening and destructive effects much more rapid than the action of acids alone is liable to accomplish. Bowditch, in examining forty persons of different professions, and living different kinds of life, found in almost all vegetable and animal parasites. The parasites were numerous in proportion to the neglect of cleanliness. The

means ordinarily employed to clean the teeth had no effect on the parasites, whilst soapy water appeared to destroy them.—*Lancet*, December 13th, 1873.

Holman's "Siphon Slide" for the microscope is composed essentially of a strip of plate-glass, three inches by one inch wide, but double the usual thickness, in the upper surface of which has been ground a shallow groove, elliptical in both its transverse and longitudinal section, and deeper towards one extremity. The excavation is so arranged as to receive a small fish, tadpole or triton, and retain it without, on the one hand, injury from undue pressure, but without, on the other, permitting any troublesome movements beneath the thin glass cover, which, when applied, forms the ceiling of the cell. The great improvement of this slide consists, however, in the imbedding of a small metallic tube (communicating with each extremity of the groove), in either end ot the slide, and the adaptation to these two tubes of pieces ot slender caoutchouc pipe, about eighteen inches in length, one of these being intended for the entrance, and the other for the exit of any fluid, *cold* or *hot*, which it might be desirable to employ.

For examination of larger reptiles, and for demonstrations with the gas-microscope, a slide four inches long, with two oval concavities, and a narrow groove more deeply cut for the body of the creature, has been devised. With such an apparatus, through which a current of ice-water can be passed, the injurious heating effect which ordinarily attends the use of calcium or electric light to illuminate living specimens is entirely counteracted.

When in use it is only necessary to place the animal with some water in the groove of the slide, cover with a sheet of thin glass, immerse the end of one of the caoutchouc tubes in a jar of water, and then, applying the mouth to the extremity of the other rubber pipe, make sufficient suction to set up a flow of the liquid through the apparatus. The stream of fluid (of course bathing the animal in the cell during its passage) can readily be kept up as in any other siphon for hours or days, and its rapidity exactly regulated by graduated pressure upon the entrance-pipe, so that in this way a triton may be examined continuously (as stated by Dr. J. Gibbons Hunt) for a whole week without material injury.

Among the great advantages of this very ingenious contrivance may be enumerated—first, its security,—the animal being prevented from escaping, and the joints of the appa-

ratus being kept tightly closed by the pressure of the atmosphere; second, its portability,—the whole preparation being made at home, carried to a lecture-room in the pocket, and exhibited to an audience hours afterwards; and third, its convenience,—this arrangement permitting the removal of the slide at any time from the microscope-stage, to make way for other experiments, and its instant readjustment when desired.

The Microscopical Society of Victoria, which, at this early stage of its existence, has a good member-roll, has held its first general meeting at Melbourne, the president (Mr. W. H. Archer) being in the chair. A rich and varied collection of microscopes and objects was shown by members of the society, and during the evening these exhibits were examined with interest. The president, in delivering his inaugural address, explained that the society would consist of two classes of persons—viz. skilled workers, who were called members, and students and amateurs, who were called associates. Mr. Archer went on to say that in Victoria there were microscopists who were possessors of good instruments, and who knew thoroughly how to use them. The establishment of this society, it was hoped, would induce most of these gentlemen to co-operate, sooner or later, with one another; for though at intervals certain very valuable special professional work had been accomplished in Melbourne and elsewhere, yet so far as published results were concerned, not only Victoria, but Australia generally, was, microscopically speaking, almost altogether an unknown land. The address was followed by some interesting statements and demonstrations, and altogether the inaugural meeting was a very successful one. The holding of ordinary meetings has commenced, and the society appears to have a useful career before it.—*London Medical Record.*

The Silver Method.—Dr. Reyher, in his paper referred to above on the cartilages and synovial membranes of joints, takes occasion to discuss the value of the silver treatment in similar investigations, and makes the following remarks:—

"As is well known, the usual interpretation of the images obtained by means of the silver treatment has been called in question by Schweigger-Seidel, and doubt has been thrown upon the cellular nature of the figures and appearances which are produced in the synovial membrane by means of this reagent. His objections have been fully answered as regards other organs (*e. g.*, the cornea), in which, with different methods of treatment, corresponding outlines are always

attainable. Whilst I am firmly convinced that the same holds good with regard to the synovial membrane, it must be remembered that, so long as neither the treatment with chloride of gold nor combined methods had been employed in the investigation of this tissue, a gap was left in the evidence as to the nature of the silver outlines. I anticipated that these methods would render service, more especially in bringing to light the exact meaning of the large white stellate fields, apparently belonging to the same category as those demonstrable in the cornea, but as to which it was uncertain whether they belonged to groups of cells or only to single ones. My investigations with respect to this point have been principally made on the joints of full-grown sheep and oxen, the tarso-metatarsal joints of which, and especially of the last-named, yield marginal zones a finger's breadth wide. The sections were always made subsequently to the occurrence of the silver precipitation; in this way the clearest images are obtained, and there is no fear of cutting sections of cartilage from which the marginal zone has been accidentally rubbed off.

"I had so often attempted, without any great measure of success, to combine the staining by other reagents, such as carmine and aniline, with that obtained by the silver method, that I was extremely pleased to find that hæmatoxylin, which I made trial of at Professor Burdon Sanderson's suggestion, furnished a perfectly reliable means of staining the cell-nuclei. By the employment of sections which are sufficiently thin to obviate any sources of fallacy arising from the presence of the nuclei of the more deeply seated cartilage cells, it is not difficult to convince oneself that the white fields on the brown ground of the silver preparation from the more circular spaces of the cartilage to the stellate and epithelioid forms of the inner layer of the capsule, each contain either one or several (violet-coloured) nuclei. By this method, then, it is demonstrable that in each of the white fields of the silver preparation there lie, according to the size of the fields, one or several cellular elements. It is, however, impossible by this means to say whether the cells entirely fill the cavities, and by means of their processes extend into the lymphatic canaliculi, forming a complete anastomosing network or not. For the elucidation of these points the treatment with gold is necessary. Thus, in two kinds of preparations, one treated by the combined silver and hæmatoxylin method, the other with gold, appearances are met with which in general form and the mode of branching of the processes are more or less similar.

As the hæmatoxylin shows the presence in the silver preparations of cell-nuclei corresponding to the whole spaces, so the treatment with gold shows that these nuclei correspond to protoplasmic bodies which—the conclusion will hardly be assailed—correspond, on the whole, to the spaces in the silver preparations. It is quite another question whether these masses of protoplasm completely fill the spaces or not. Proof of this could only be obtained were it possible to produce both the gold and the silver appearances in the same preparations. As is well known, however, if a preparation be treated first with silver, then with gold, the effect is only to produce a reduction of the latter in the parts impregnated with silver, whilst the converse mode of treatment altogether fails to yield the silver spaces. The question must, therefore, so far remain unsettled. All one can say is, that on both silver and gold preparations appearances are frequently obtained which, as regards form, are precisely similar, apparently even to the minutest details, although it is not everywhere possible to trace the same exact resemblance; for instance, the protoplasmic masses of the one might be said to be smaller relatively than the spaces of the other; the sizes, however, in both are so varied that it is difficult to compare them. If the forms obtained by the gold treatment differ from those obtained by the silver treatment, in one point more than in another, it is in the diameter of the processes, which here and there appear somewhat smaller and more tapering than those proceeding from the spaces of the silver preparation. On the other hand, the appearances presented in silver preparations which have been placed in spirit are in favour of the idea that the spaces are completely filled by protoplasm. In these it occurs here and there, although it must be admitted, not generally, that both nucleus and protoplasm may be made out, the latter appearing as a finely granular substance, which is separated from the brown intercellular substance by a crescentic clear zone or space (perhaps caused by a shrinking of the protoplasm). We may conclude, therefore, that the white spaces and canaliculi shown to exist in the synovial membrane by treatment with nitrate of silver, correspond generally to a protoplasmic network (made evident by chloride of gold), consisting of connective-tissue-corpuscles.

A similar statement may be made with regard to the cartilage-cells of the surface, which appear after treatment with silver as round white spaces, in which hæmatoxylin brings the nuclei into view; whilst, on the other hand, chloride of gold colours the protoplasm of the cells.

Bacteria in Malignant Pustule.—The fatal malady known by this name amongst ourselves, and when it occurs in cattle as "the Blood," to which the French give the name of Charbon, and the Germans that of Milzbrand, though happily rare in England, does occur occasionally amongst cowkeepers, butchers, and others who have to do with cattle or horses; and on this account the careful description of two such cases, given by Dr. B. Fränkel and Dr. J. Orth, in the 'Berliner Klinische Wochenschrift' for June 1st and 8th, 1874, deserves attention.

Both patients were admitted into the Augusta Hospital at Berlin, the second being a sick-warder and *post-mortem* room assistant in that institution. Both cases were fatal. At the *post-mortem* examination of the first the following appearances were found:

The whole of the cervical connective tissue was infiltrated with reddish serum. This sanguineous infiltration, following the course of the trachea, extended into the mediastinum, along the bronchi, and over the pericardium. Everywhere, along with this œdema, the lymphatic glands were enlarged, some to the size of walnuts, and so swollen with dark blood as to strongly resemble blood-clots. The spleen was much enlarged, and extremely soft. The whole mucous membrane of the stomach was greatly swollen, pulpy, and reddened. In five or six large spots there was especial swelling, partly due to extravasated blood, partly to local gangrene, with a greenish-yellow tint. This appeared, not only on the surface, but on section. Professor Virchow pronounced the case to be one of malignant pustule directly he saw this stomach. The microscope confirmed this, for not only on the surface of these greenish-yellow spots, but also in the parenchyma of the gastric walls, there were found enormous quantities of the parasitic elements generally known by Davaine's name of Bacteridia. For the most part these appeared as masses of felted, but not branching, threads, which were seen, at the edges of the groups, to be composed of a number of little rod-like bodies of equal length. There were also masses, though less numerous, composed of groups of equal-sized granules (micrococci). It was now clear that the case was one of the so-called mycosis intestinalis, a special form of the pest known as *Milzbrand*, or spleen-gangrene, or malignant pustule; and the marked swelling and hæmorrhagic appearances of the mesenteric and retro-peritoneal lymphatic glands, the softened spleen, sanguineous œdema of the connective tissue of the abdominal cavity, ascites, &c., described by Dr. Fränkel, perfectly agreed with

the descriptions given by other observers (see E. Wagner, 'Archiv der Heilkunde,' 1874).

The appearances in the second case were very similar, as regards the lymphatics, &c. The appearances in the abdomen were like those in the last case, including the stomach. The spleen was enlarged and softened. Bacteridia in masses were found in the blood of the heart (examined at once), and on the next day in a mesenteric vein. The white corpuscles were increased. No movements were seen in these bacteridia; but that they were not coagula of any kind was shown by their having kept perfectly well for some months with acetic acid. The blood had carried these into all the organs, but in the gangrenous-looking spots in the intestines there were no rods or fibres, but heaps of micrococci.

This is the first published case of direct communication from man to man, though Lube and Müller's cases ('Deutsches Archiv für Klin. Med.') show that such transmission has been suspected. Dr. Orth inoculated a rabbit with the fresh blood of the second case, and from this one another, and so on, till eight were injected. Masses of bacteridia were found in the blood and connective tissue of all these animals. —*Medical Record.*

QUARTERLY CHRONICLE OF MICROSCOPICAL SCIENCE.

BOTANY.

I. Algæ.—1. *Spores of Nostochaceæ.*—In a paper ('Ann. des Sc. Nat.,' 5e sér., xix, p. 119) on the reproduction of some species of this group belonging to the genera *Spermosira* and *Nostoc,* Janczewski announces the discovery of spores in the latter genus, an observation already anticipated by Archer in *Nostoc paludosum,* one of the species in which it has now again been detected (' Quart. Journ. Micr. Sc.,' 1872, p. 367). In a subsequent number of the volume, Bornet (p. 318) confirms this discovery in numerous other species. He had already in his memoir published, in the seventeenth volume, announced the reproduction by spores of *Glœocapsa.*

2. *Conjugation of Zoospores in Confervaceæ.*—Areschoug has recorded the interesting fact (' Act. Reg. Soc. Sc. Ups.,' ser. iii, vol. ix) of the conjugation of the zoospores of various *Confervaceæ ;* amongst others, of two very widely diffused species—*Cladophora sericea* and *Enteromorpha compressa.*

3. *Morphological Differentiation of the Sphacelaria-series.*—i. Pringsheim points out (' Abhl. der k. Akad. d. Wiss. zu Berlin,' 1873) that some Thallophytes offer distinct transitions to a cormophytic mode of bud-formation. These increase in interest when they occur as terminal links of a series, for it appears natural to assume that such a series corresponds to the genetic progress of development of the forms, and indicates the various paths which have led on to cormophytic bud-formation. In the different subdivisions of the Algæ, several progressive and parallel series lead from the simple confervoid type of growth up to bud-structure. Amongst the *Florideæ* the *Ceramium*-series affords an example.

A far more perfectly developed and almost rectilineal series is presented by the *Sphacelaria*-series, belonging to *Phæosporeæ.* It comprehends the *Ectocarpeæ,* the *Sphacelarieæ* proper, and some smaller genera. The final link of this series, *Cladostephus,* shows a great approximation in its mode of growth to cormophytes. The *Ectocarpeæ,* which form the lowest links of the series, are plants of purely confervoid

growth. The middle links of the series, the *Sphacelarieæ*, and the genera *Halopteris*, *Stypocaulon*, &c., are more and more differentiated in their structure, and, in the morphological distinctions of their systems of ramification, almost step by step approach the bud-like jointing and the structure of *Cladostephus*. Thus the manner in which the *Sphacelaria*-series attains in *Cladostephus* its more distinct and established cormophytic configuration, seems well suited to illustrate certain correlations between the anatomical structure, the origin, and the configuration of the systems of ramifications. As the basis for the comparison, Pringsheim copiously describes two of the links in the *Sphacelaria*-series in respect to their structure and the development of their systems of ramification; *Cladostephus verticillatus* as the most perfectly differentiated link in the series, and *Sphacelaria olivacea* as one of the lower forms in which the differentiation of the ramification has scarcely advanced.

The first differences which occur in the forms of ramification in this series, commencing with the confervoid type, are presented by the formation of the fruit, and begin vegetatively by the formation of trichoma-like apices and independent trichomata. Both appear only as portions of branches, originally uniform, but checked and modified in their growth. In a further stage entire branches suffer these modifications. Further differences afterwards appear between the purely vegetative branch-forms. In this stage (of which the *Sphacelarieæ* proper present numerous examples) we meet with branches close together, in some of which the growth becomes extinguished earlier than in others. By degrees these differences increase in *Chætopteris*, *Halopteris*, *Stypocaulon*. Still later further differences amongst the limited and unlimited ramifications become more definitely distinguished, and the systems of ramification in the final link of the whole series, the genus *Cladostephus*, become sharply separated into the different modifications of branch and leaf-forms. A distinct connection of the morphological configuration with the structure and the origin of the bud-formation does not admit of being overlooked.

The first indications of a differentiation in the ramifications occur in the purely confervoid *Ectocarpus*-species, which still show no kind of differentiation of their tissue. These morphological distinctions only become noticeable with the distinct separation of the tissue into permanent and formative cells, and especially with the advancing localisation of the latter at the apex of the thallome, and with the separation of the tissue of the axis into central and peri-

pheral portions, entailing a more and more sharply expressed differentiated origin of the lateral buds from unequivalent elements of the tissue.

In the smaller *Sphacelarieæ*, growing with an apical cell, the origin of the thallome-branches does not appear connected with any definite position. In the further advanced links of the series (*Halopteris*, *Stypocaulon*, *Chætopteris*) the differentiation of the purely vegetative branch-forms become more considerable, but still exhibits numerous transition-stages. Also the thallome-forms originate at definite places of the mother-axis; but still the places of origin of the thallome-forms are common to several of them. Adventitious buds make their appearance besides the normal ramifications.

In the most highly differentiated terminal links of the series, the *Cladostephus*-species, we finally see all these differentiations of the thallome-forms constant, and their place of origin definite. With the differentiation, also the variety of the thallome-forms has increased. Normal ramifications and adventitious buds, leaves and fruit-leaves, fruit-branches, hairs and root-threads, occur as completely individualised and strictly distinct thallome-forms, and each of these has its separate place of origin. In *Cladostephus* the normal ramifications proceed from dichotomy of the apex, the adventitious buds from the central cells of the axis, the leaves from the oldest cortical cells, the fruit-leaves—that is to say, a higher stage of the leaf-metamorphosis—from the youngest cells of the cortex, the hairs from the apex of the tip of the leaf, the fruit-branches from the joints of the fruit-leaves.

ii. *Cladostephus verticillatus* is a perennial whose buds possess a normal vegetation-pause, just like shrubs and trees. It consists of a system of dichotomously branched stems beset by numerous many-jointed whorls of leaves. The stems and leaves grow by successive subdivisions of their apical cells. By the division of these primary joint-cells secondary joint-cells are formed by means of walls following each other in definite sequence and direction; in this way also the tissue of the joints is differentiated into medulla and cortex.

In the production of branches by dichotomy the apical cell is divided into three portions—two new apical cells and a terminal portion of the old axis. A portion of the apical cell is first cut off by a septum directed obliquely and laterally from its apex. This newly formed cell is the mother-cell of one of the commencing bifurcations. In the remaining por-

tion of the old apical cell a second septum originates vertical to the first and directed to the opposite side; this forms the mother-cell of the second bifurcation. The lower portion remains the basis of the bifurcation, and afterwards, by cellular increase, gives rise to a special portion of the divided stem—the "ramification-node."

In *Halopteris* the apical cell produces, not branches exclusively, but sometimes leaves, sometimes branches, according, apparently, as the lateral septum cuts off a smaller or larger portion of the apical cell. Here only a single new direction of growth takes place, only one septum is formed, the old apical cell merely becomes deflected, but still remains as apical cell.

The adventitious buds originate from the joints; the quadrant-cell ("innovation-cell" or "brood-cell") which is to give rise to one does not form any cortical cells. In some of the lower genera these adventitious buds show a regular arrangement, but in *Cladostephus* this is not the case. The connection of the medullary tissue in the stem and adventitious bud is produced by the first medullary cells within the rudimentary adventitious buds reaching to the centre of the stem, and appearing as lateral branches of the medullary region of the stem. Hence there does not exist, as in the case of dichotomy, any "ramification-node" belonging in common to both branches, but at the place of ramification a new first joint belonging to the branch is laterally apposed to the stem-joint.

The leaves in *Cladostephus* originate exclusively from the peripheral cells of the joints. The first peripheral cells which are produced are the mother-cells of the leaves and of the cortex. These cells behave as apical cells, and are divided by transverse septa. The first of the cells so formed give rise to the primary cortex of the stem, and may be designated "leaf-bases;" their upper divisions appear to form a transition between cortex and leaf, and may be described as the "basilar node" of the leaf. Some cells of the basilar node may occasionally grow out in a papilla-like manner, and form a second leaf. These may give rise to whorls of "supplementary leaves." By repeated radial subdivisions of the cortical cells of the joints in *Cladostephus* the origin of the leaves becomes deeply immersed in secondary cortex. The further growth of the leaves takes place by subdivisions of primary cells produced by division of the apical cell. In the immersed basilar joints the division of the secondary cells for the formation of the cortical and medullary tissues are analogous to those of the stems. In the free middle leaf-

joints the medulla becomes reduced to a single large cell. The terminal joints become attenuated, and often spine-like; in other cases, however, they become cellular, or end club-shaped. In the formation of the cortex of the leaf-joints no general rule prevails. The formation of "hairs" is restricted to the axil of the leaf-tip. The leaves of *Cladostephus* branch by a division of the apical cell similar to that of the axis in *Halopteris*.

Cladostephus possesses, besides vegetative "leaves," a second form of leaves, or "fruit-leaves." These were regarded by their first observers as a foreign epiphytic growth, and described by them under the name of *Sphacelaria Bertiana*. They originate only at the end of the period of vegetation on the old joints, after all increase in the thickness has completely ceased; their configuration is much simpler than that of the foliage leaves. The outermost peripheral cells of the internodes of the old joints are the mother-cells of the fruit-leaves; they grow out in a papilla-like manner, and become the apical cells of these organs. They ordinarily bear the sporangia on special "fruit-branches;" more rarely the apex of the fruit-leaf itself becomes the fruit-branch. They are ramifications of the undivided joint-cells, or, more usually, of the "innovation-cells" of the lower and middle joints of the fruit-leaves. These innovation-cells grow out laterally from the joints of the fruit-leaf, and become the apical cells of the fruit-branches. The number of their joints varies from one to eight. The resulting uni- and multilocular sporangia are distributed on different plants. The former are terminal, the apical cell increasing in size, and its contents emerging *en masse*, enclosed in a common mucus, presently breaking up into zoospores. The supporting cell of the sporangium may continue growing as a new apical cell, and thus the younger sporangia may come to be surrounded by the empty coats of several older sporangia. The multilocular sporangia are likewise terminal; the apical cell becomes divided into 3-5-celled series; the individual cells, by repeated vertical and horizontal divisions, give rise to the mother-cells of the zoospores, one in each. The zoospores are not emitted *en masse*, but each forms its own mother-cell; they do not appreciably differ from those of the other kind of sporangium, and resemble those of other *Phæosporeæ*. They possess two cilia—one, the longer, directed in front, the other behind.

About the end of November (at Genoa) the vegetation-pause in *Cladostephus* commences. Some of the buds remain dormant, and resume their growth the following year. This

may be effected by certain cells persisting as "innovation-cells," and growing into adventitious buds next year, or the apical cell of the old bud continues unaltered during the vegetation-pause to eventually resume its growth.

iii. *Sphacelaria olivacea*, Dillw., shows in the structure and development of its stem and branches no essential differentiation beyond that of size; the latter are, without exception, products of the joint-cells. The unilocular sporangia occur on the smaller branches, whose terminal cells, as in *Cladostephus*, swell up directly to form them; the supporting cell also grows through, but gives rise, not to a new sporangium, but to a new branch. Besides these certain lateral branches, shorter than the merely vegetative, modify their terminal cell into globular sporangia, whose contents become divided into cubical cells. Pringsheim has reason to think that the zoospores in the unilocular sporangia arise in a transitory cell-net. Hence he is led to the conclusion that the difference between the two sporangial forms in the *Phæosporeæ* is not an absolute one, but only expresses a different degree of persistence in the mother-cell-tissue; consequently, this second form of sporangia in *S. olivacea* may be comparable to multilocular sporangia. *S. olivacea* would therefore seem to be a species in which the definitive separation of the two sporangium forms is not yet fixed, but only about to be originated.

Other asexual modes of increase occur. Amongst these are the three-four-rayed gemmæ (Brutknospe). These, as regards position, structure, and morphology, are manifestly metamorphosed fruit-branches; they fall off, grow to new plants, and are thus comparable to the gemmæ of mosses and liverworts. After separating from it, their supporting cell grows out again, to produce a cell higher up than the last, a new gemma.—W. ARCHER.

4. *Batrachospermum.*—Sirodot ('Comptes Rendus,' May and June, 1873) finds that *Chantransia* is an asexual generation, which is developed from the sexually produced spores of *Batrachospermum.*

5. *Parasitic Algæ.*—Kny ('Sitz. der Gesellsch. Natur. Fr. zu Berlin,' Nov., 1872) describes two additional instances of algæ with a parasitic habit. On examining, in September, 1872, at Heligoland, decayed specimens of *Delesseria sanguinea*, of which the fronds had to a great extent decayed, leaving only the midribs beset with adventitious sprouts, he met with examples showing abnormal brown bands and spots. On making thin superficial sections through these portions he found that they were covered by an irregular network of

delicate-jointed branching filaments. From the examination of transverse sections it was readily seen that the filaments passed into the tissues of the *Delesseria,* penetrating the cuticle, and pressing asunder the subjacent cells, thence finding their way into the intercellular spaces.

Kny subsequently found similar filaments in the interior of other *Florideæ,* as also in *Laminaria saccharina.* He discovered no fructification, but the superficial filaments had their parietal protoplasm tinged uniformly with a brownish-yellow colouring material which in the internal filament was granular. He supposed the plant to belong to the *Phæosporeæ.*

In *Polyides rotundus* Kny found red sterile filaments, which he conjectured to belong to *Florideæ.*—W. Archer.

II. Fungi.—1. *Ancylisteæ, a new group of Phycomycetes.*—Pfitzer has described in great detail the life-history of *Ancylistes,* a new aquatic parasite, and the type of a new group, in the 'Monatsb. der Akad. der Wiss. zu Berlin,' 1872, p. 379. In August, 1871, he met with examples of *Closterium acerosum,* Ehr., which appeared to have been to a great extent killed by a parasite. In the spring of the following year he was able to follow out its history. In the interior of living Closteria, between the chlorophyll-plates, were found from one to eight extremely slender, delicately bounded cylindical and colourless bodies, of about 0·01 mm. in thickness, permeating the cell from end to end. They appeared to consist of plasma without a cell membrane, but containing minute granules, which moved in various directions but without altering the form of the plasma-mass. Ultimately they acquired a cell-membrane, and were then divided by septa into a number of longish cylindrical cells. The infected individuals of *Closterium* at first retained much of their ordinary appearance; the starch-granules, however, first disappeared, and the death of the host-plant finally ensued on the further development of the parasite. Each of its constituent cells sent out from near one end a short blunt process, which perforating the wall of the *Closterium*—mostly on the same side—projected outwards as so many papillæ, which eventually grew out into elongate hyphæ, into which by degrees the plasma passed. The hyphæ were found, by actual measurement, to exhibit an apical growth of ·01 mm. in a minute; very rarely they became branched.

As soon as a hypha came in contact with a neighbouring *Closterium* its apex became enlarged and firmly attached. The plasma passed up into the enlarged apex, which was once more cut off by a septum from the

remaining portion of the hypha. In a few hours the parasite began to perforate the membrane of the *Closterium;* this finally effected a thin process from the extremity of the parasite passed into its cavity. A minute colourless, gradually increasing globule terminated the filament, and the plasma by degrees passed into it. Ultimately it separated from the filament, elongated itself in the direction of the axis of the *Closterium,* and in a few days grew into one of the long cylindrical bodies described at the commencement.

In addition to this alternation of vegetative generations there occurred finally a sexual one. When the formation of hyphæ has gone on for some time, individual Closteria are found to contain parasitic cells of two forms. One resembles that of the divided cells already described, but somewhat thicker; the others are at once distinguishable by being considerably narrower. The *Closterium* now dies, and the thinner cells contained in it send out towards their thicker neighbours slender lateral processes, which sometimes become septate. Resorption takes place where the hyphæ come in contact, and although a backward and forward movement takes place between the plasma of the two connected bodies, the aggregate mass is at last gradually retracted into the larger cell, which is now, in fact, an oogonium. This becomes somewhat inflated, and the contents retracted from the wall and shut off by a septum at either end; this process may be several times repeated, each time the contracting contents leaving behind a septum, until finally the oogonium consists of a nearly round central cell, and two to four lateral cells containing fluid only. The contents of the central cell again contract, and become surrounded by a new wall or exosporium.—W. Archer.

2. *New types allied to Chytridieæ.*—N. Sorokin has described ('Bot. Zeit.,' 1874, May 15), from the neighbourhood of Kazan (Russia), two new and singular species closely allied to *Chytridieæ.* The first, *Zygochytrium aurantiacum,* produced on dead insects in water an orange-red gelatinous coating. This consisted of a mass of a fungoid plant of great simplicity. A single tubular stem-cell was expanded at its base into a lobed organ of attachment or foot, while it divided above into two branches, each bearing an ovoid operculate sporangial cell. Beneath each sporangium a short bluntly pointed lateral branch—the "appendix"—was given off, but its function remained uncertain. The whole plant was filled with golden-yellow protoplasm, containing vermilion granules, and enclosed in a colourless membrane. In

the formation of zoospores the protoplasmic mass became contracted towards the upper part of the sporangium, the operculum was thrown off, and the protoplasmic mass was discharged as a rounded naked body, which in about fifteen minutes became coated with a delicate cell-wall. The red granules were first collected towards its centre, but were subsequently equally distributed, and the protoplasm subdivided into individualised portions, each containing a granule, and which were finally set free as rapidly moving zoospores with a posterior cilium. The zoospores ceased to move, became amœboid, the cilium was drawn in, and the zoospore in a few minutes began to germinate. This was effected by its elongating into a tube, developing a foot at one end and dichotomously branching at the other. Besides the production of zoospores, zygospores, of a blood-red colour, very thick-walled and covered by irregular protuberances, were formed by the conjugation of two horizontal lateral branches thrown out from the two ramifications of the plant. These germinated very readily.

A second nearly related form (*Tetrachytrium triceps*) was found on various submerged objects, with cell-contents of a greyish-blue. The stem-cell was also furnished with a foot, and divided above into three branches, each bearing an operculate zoosporangium, and beneath them an involuted "appendix." The zoosporangium discharged its protoplasmic contents as before, but then separated into only four portions, which were ultimately set free by the rupture of the mother-cell-wall, as four blue-coloured bodies with a median clear spot. They did not exhibit any amœboid movements on coming to rest, but conjugated in pairs. Zoospores, which were unable to conjugate, never germinated, but the zygospores readily germinated, reproducing the plant with its triple branches and "appendix."

These two organisms appear to differ from *Chytridieæ*, on the one hand, in the presence of zygospores in *Zygochytrium*, and the conjugation of the zoospores in *Tetrachytrium*. The author considers that these new types may form a special natural group, with *Chytridieæ*, *Ancylisteæ*, *Saprolegnieæ*, *Zygomycetes* (*Mucorini*), and *Peronosporeæ*, for which he proposes the name SIPHOMYCETES. Of this group, *Amœbidium*, Cienk., may be regarded as the simplest form ('Bot. Zeit.,' 1861, p. 169).

The author announces his intention of describing the whole group in a forthcoming work, which microscopists will be glad to know is almost completed.—W. ARCHER.

3. *Hemileia.—The Ceylon Coffee Fungus.*—Owing to the

misapprehension which still largely exists as to the real nature of the coffee leaf disease (*Hemileia vastatrix*), and the erroneous views and wild conjectures propagated respecting it, I feel that it is desirable I should again offer some observations on the subject. The disease consists in the parasitic growth within the coffee-tree of a well-defined species of fungus, originated and reproduced by means of spores, easily identified by employment of the microscope, and thus readily distinguishable from every other known fungus. There can be no question that this fungus is communicated from coffee plant to coffee plant through dissemination of the spores, and that it may be conveyed by the wind, or by streams of water, or by animals of any kind moving from place to place. The fungus has only yet been detected, in a definitely organised form, in the cellular tissue of the coffee leaf, lying immediately under the diseased spots, in the spores themselves, and in the filaments produced by the germinating spores. The fungus would appear, however, to be present in the growing tissues generally of the coffee plant in a diffused form, altering the character of the cell-contents, and thus producing the stains observable on the bark of the young branches, and the pale somewhat translucent spots to be seen in the leaves previously to the outbreak of the orange-coloured spores.

Investigations with the microscope with reference to the germination of the fungus spores have been made by my friend, the Rev. R. Abbay, and by myself. The process has been observed by both of us. Mature spores removed from a diseased coffee leaf and laid upon charcoal kept constantly moist, commence to germinate in a few days. The germination consists in the spore becoming somewhat enlarged, and its contents converted into one or more globular translucent masses. From each of the latter a filament is developed, which grows very rapidly, and becomes more or less branched. At the termination of some of these branches secondary spores are produced in the form of radiating necklace-shaped strings of little spherical bodies of uniform size, and this form closely resembles the fructification of an *Aspergillus*. Mr. Abbay has also observed another form of secondary spores arranged in single rows of spherical bodies, a good deal larger than those radiately arranged, but still exceedingly minute. These inconceivably numerous secondary spores may be easily carried by the wind into surrounding districts, and thus convey infection to distant plantations.

The effect of the fungus upon the coffee-tree would seem

to be the gradual loss of vital energy. The tree, after the first attack of the disease, which is often apparently the most severe, throws out fresh healthy-looking leaves, and exhibits for a certain period the appearance of having perfectly recovered. These fresh leaves, however, after the expiration of a few months, exhibit the characteristic spotting, and, as on the previous attack, fall prematurely. These repeated attacks occurring periodically, at length seriously affect the health of the tree if old and ill-cultivated, and it becomes of little or no value as a crop-producer. There is great reason to believe, however, from what has been observed, that high cultivation, with judicious manuring, enables the tree to better sustain the attacks of the fungus, and to retain strength and vigour enough to produce a fair yield of berry. It is indeed ardently to be hoped that this beneficial effect will be permanent.

Whether each outburst of the disease implies a fresh introduction of the parasite into the coffee plant, or merely a periodical spore production of a permanent parasitism, remains to be discovered. It is just possible to imagine some subtle destructive agency operating, in addition to the little red maggot which feeds on the spores, to arrest the development of the fungus, but there is nothing to support such a view at present.—*From Dr. Thwaites' Annual Report of the Peradeniya Botanic Gardens.*

4. *Heterœcism.*—Dr. Wolff announces that *Peridermium Pini*, Lév., is the æcidiosporous state of *Coleosporium Compositarum*, Lév., forma *Senecionis* ('Bot. Zeit.,' 1874, p. 184).

5. *Development of the Rye-Smut, Urocystis occulta,* Rabh.—Dr. Reinhold Wolff gives an elaborate paper on this subject, illustrated by a plate, in the *Botanische Zeitung,* for Oct. 17-31, 1873. The species is known in Europe only as a parasite on the rye (but in Australia occurs also on the wheat), penetrating into the cellular tissue of the leaf, leaf-sheath and culm, between the vascular bundles. (Cooke, however, states that it occurs also on the leaves of *Carex.*) The spores are generally collected in groups, with other smaller spore-like bodies attached to them, but are occasionally found simply without any of these appendages, and can then only be recognised after germination. Germination takes place after three or four days, the pro-mycelium filled with five-grained protoplasm bursting through the epispore, and forming at its extremity, by a peculiar process of division, from two to six "sporidia," about equal in length to the pro-mycelium, which then become separated from it by a septum after all the protoplasmic contents of the pro-

mycelium have passed into them. From these sporidia (before they have become separated from the pro-mycelium) the elongated germinating filaments are developed, the protoplasm gradually accumulating towards the growing apex, which becomes separated by a septum from the posterior part. Both sporidia and germinating filaments have the power of penetrating the epidermis to reach the cellular tissue of the host. But when the apex of the filament has penetrated into the interior of a cell, it does not grow free in its cavity, but becomes enclosed by the inner layers of the cell-wall as by a sheath. This sheath shows the ordinary reaction of cellulose, and can often only be recognised by treating the preparation with potash, covering, as it does, every branch of the germinating filament of the parasite as it ramifies. The mycelium of the *Urocystis* takes from eight to ten weeks to become fully developed. The ends of the filaments then swell greatly, and become filled with protoplasm, but without dividing, the terminal portions of several filaments become closely attached to one another, and form a kind of ball which gradually becomes uniformly filled with a fine-grained protoplasm, containing drops of oil, and enveloped in a membrane. This ball finally develops into the group of spores with its peculiar spore-like appendages, which appear to be the detached apices of other filaments of the mycelium.—A. W. BENNETT.

6. *Penicillium glaucum*.—Brefeld gives in 'Flora,' 1873, p. 331, a short account of the results, fuller detailed in his recently published memoir on this "asexually propagated form of a hitherto unknown species of the group of *Ascomycetes*."

Mucor racemosus and Yeast.—Brefeld contributes to 'Flora' (1873, p. 385) a paper on this subject, with some remarks on the systematic arrangement of Fungi.

7. *Protomyces microsporus*, Ung.—In the 'Botanische Zeitung' for February De Bary describes in detail the history of this species. *Protomyces macrosporus*, Ung., remains the type of a family of doubtful affinity, but *P. microsporus*, now *Entyloma Ungerianum*, De Bary, is shown to be clearly entitled to a place amongst *Ustilagineæ*.

III. Lichens.—The literature of the lichen-question has been fully noticed in this Journal. Bornet has added an additional confirmation to the theory which daily gains ground in a note ('Ann. des Sc. Nat.,' 5e sér., xix, p. 314), in which he announces that he has met with cases in which *Trentepohlia* (*Chroolepus*, Auct.), which constitutes the gonidia of *Opegrapha*, has emerged from the lichen, resumed its normal

structure, and produced sporangia from which zoospores were discharged. He has also met with cases in which *Collema* produced young individuals of *Nostoc* by a kind of pullulation.

IV. **Hepaticæ.**— Kienitz-Gerloff has published ('Bot. Zeit.,' March and April, 1874) the result of his studies in the development of the sporogonium of *Riccia*, *Marchantia*, *Preissia*, *Pellia*, *Metzgeria*, *Frullania*, *Radula*, *Liochlæna*, *Lepidozia*, *Jungermannia*, and *Calypogeia*.

V. **Marattiaceæ.** — 1. *Angiopteris.* — Tchistiakoff has republished ('Ann. des Sc. Nat.,' 5e sér., xix, p. 219) an elaborate memoir originally printed in Russian on the development of the sporangia and spores of *Angiopteris*. The purport of the research is rather to throw light on the general theory of the vegetable cell. The detailed observations differ in some respects from those of Luerssen and Russow. The theoretical considerations are in harmony with those of Brucke and Hanstein in regarding the protoplasm as an organism inferior to an amœba because deprived of its individualisation. The nucleus and nucleolus are regarded as structures brought about by the equilibrium of forces to which the protoplasm is exposed, and are therefore by no means characteristic of it in its most active condition.

2. *Scolecopteris.*—E. Strasburger describes in the 'Jenaische Zeitschrift' (1874, pp. 81-95) the structure (especially of the sporangia) of *Scolecopteris elegans*, Zenk., a species of *Marattiaceæ* from the Permian of Chemnitz. The details were perfectly preserved in chalcedony, which allowed admirable sections to be studied. In an additional plate he figures the structure of the sori of *Angiopteris evecta*, and *Marattia Kaulfussii*.

VI. **Lycopodiaceæ.**— *Asterophyllites.*— Prof. Williamson has described the histology of this very remarkable extinct type in an elaborate memoir ('Phil. Trans.,' 1874, pp. 41—81) with illustrative plates.

The Oldham form in its youngest state first appears as a mere twig, having a central vascular axis enclosed in a cortex. The vascular axis consists of reticulated vessels; its transverse section is triangular. The cortex consists of an outer prosenchymatous (sclerenchyma?) and an inner parenchymatous layer. As the plant grew successive vascular layers appear to have been added to the exterior of the vascular axis. In the Burntisland type the features were essentially the same, but the vessels were barred and not reticulate. The fructification already described by the author as *Volkmannia Dawsoni* is now regarded by him as

belonging to *Asterophyllites*, and he suggests that the curious spinous bodies from the coal measures described by Mr. Carruthers as a carboniferous type of Radiolarians may be the spores of this plant. The *Volkmannia Binneyi* of Carruthers, who with Binney and Schimper had referred it to *Calamites*, Williamson supposes also to belong to a species of *Asterophyllites*. Carruthers has described the spores as furnished with elaters, which was a strong point in favour of their equisetaceous affinity, but Williamson "rejects this interpretation, regarding the so-called elaters as merely the torn fragments of the ruptured mother-cells in which the true spores have been developed." *Asterophyllites* appears, therefore, to belong to an extinct type of *Lycopodiaceæ*, its axial structures having some points in resemblance with the existing *Psilotum triquetrum*.

VII. Phanerogams.—1. *Trichomes.*—Oscar Uhlworm in a series of papers in the last four numbers of the 'Botanische Zeitung' for 1873 discusses the development of Trichomes especially in reference to the formation of prickles.

2. *Lenticels.*—E. Stahl describes the development and anatomy of lenticels ('Bot. Zeit.,' 1873, 577, 593, 609).

3. *Chlorophyll.*—i. G. Briosi describes the normal formation of fatty matter in chlorophyll ('Bot. Zeit.,' 1873, 545). ii. Prillieux ('Ann. des Sc. Nat.,' 5e sér., xix, 108) has carefully studied the curious observation first made by Wiesner that *Neottia Nidus-avis* becomes green on immersion in alcohol, and afterwards communicates its colour to the liquid. He finds that the brown colour of the plant is due to crystalloids or minute corpuscles with a crystalline figure, which they, however, lose in consequence of swelling when the composition of the cell-sap is notably altered. When these crystalloids are treated with alcohol or acids or the plant is immersed in boiling water, they become green by the production of chlorophyll. Prillieux, however, altogether doubts whether this chlorophyll is present in the crystalloids previously in a disguised state, and finds no reason for believing that it performs any physiological role.

4. *Crystals in Cells.*—Vesque ('Ann. des Sc. Nat.,' 5e sér., xix, 310) has succeeded in reproducing some of the forms of calcium oxalate met with in plants. In a 5 per cent. solution of glucose and a 2 per cent. solution of dextrine he obtained raphides, while in acid solutions he obtained simple oblique prisms.

5. *Parasites.*—Count Solms-Laubach describes in the 'Botanische Zeitung' for January the 'thallus' of *Pilostyles*

Haussknechtii, Boiss, a small Rafflesiaceous parasite which lives upon species of *Astragalus* in Syria and Kurdistan.

6. *Ramification and Partition of Punctum Vegetationis.*—E. Warming has published an elaborate memoir on this subject with eleven plates and a French *résumé* ('Vid. Selsk. Skr.' 5 R. Naturv. Math. Afd., 10 Bd.). The *punctum vegetationis* is that region the *special* function of the cells of which is to furnish new cells to the plant or its organs. It, therefore, does not include regions the functions of whose cells is the genesis of lateral organs, or of particular tissues in the interior of organs. The terminal cells ("schietelzellen"), or homologous groups of cells, are therefore the *puncta vegetationis* of Cryptogams, and the group of apical cells discovered by Hanstein in Phanerogams ("scheitelzellgruppe") is equivalent. Defined in this sense the inferior limit of the region will somewhat vary. If it is held to be limited by the uppermost cell of the procambium, it may be found below the highest lateral structures of the stem, especially if these happen to be buds without subtending leaves.

Warming's investigations on the histology of the summit of the stem quite confirm those of Hanstein. In all the phanerogamic plants which he has examined he found it covered with a layer of dermatogen divided usually only by radial partitions and sharply defined on its inner contour. A single terminal cell never occurs even in *Utricularia* comparable with that of Cryptogams. Of the three systems of meristem in the stem the dermatogen is the most constant and the best characterised; it is never absent even when the periblem and plerome are undifferentiated. Generally speaking, the dermatogen covers a more or less regular cellular tissue. Immediately beneath it are 1-7 layers of periblem which cover the top of the stem like a sheath, and of which the cells are usually divided by radiating partitions. Below these layers the stem is ordinarily composed of plerome—the mother-meristem of the fibro-vascular system and the pith—the cells of which are usually arranged more or less vertically and regularly. Warming has not succeeded in detecting in the different layers of periblem the cell, or group of cells, which might be regarded as the *punctum vegetationis* of each layer. But the series of cells of the plerome terminate above by a group of cells segmented in all directions and forming a tissue more or less irregular. This "initial group" of the plerome may even consist of a small number of cells arranged with great regularity or (as in the peculiar shoots of *Utricularia* studied by Pringsheim) of a single cell, but

there appears to be no reason for accepting with Sanio the existence of a terminal cell to the plerome segmented after the fashion of the terminal cell in Cryptogams.

In many cases the essential distinction between periblem and plerome cannot be recognised. The external layers of periblem give origin, in all cases, to the phyllomes. According to Hanstein, they originate in the second, third, and fourth layers, but Warming considers that it is only exceptionally that the first layer does not also take part, especially in the case of floral leaves, and that in some cases this is the only one that is active. The dermatogen also plays an essential part in the formation of leaves, especially the floral; in many cases the bracts, stipules, and bud-scales consist principally of epidermis.

Hofmeister appears to have been wrong in supposing that buds are always formed on the summit of the stem. Usually vegetative buds envelope *after* their subtending leaf; in *Æsculus*, *Syringa*, etc., it is easy to show that there are 1-4 pairs of leaves above those of the axils, of which the first segmentations for the formation of a bud have taken place. In the case of inflorescences the highest new structure developed from the stem is frequently a bud, which may arise before, simultaneously with, or after its subtending leaf, or without there ever being even a trace of this as in *Cruciferæ* and *Compositæ*. The question then arises whether these buds—originating, as they do, on the summit of the stem—are to be considered as formed by a partition of the *punctum vegetationis*. Generally speaking, however, especially when the apex of the stem is very conical, it is easy to make out that the buds which originate at the base of the cone are below the group of apical cells, forming the true *punctum vegetationis* (as in *Compositæ*). In a small number of cases buds originate so near the actual summit of the stem that the peripheral cells of the *punctum vegetationis* actually do take part in their formation.

In some such cases there is a true dichotomy of the vegetative point; its cells divide into two or more groups, and each of these becomes a point of departure for a new formation of buds. This has been ascertained in *Hydrocharis* and *Vallisneria*, in the ramification of the tendrils and less distinctly of the principal axis of *Vitis vulpina*, in the inflorescences of *Aslepiadaceæ*, in the scorpioid cymes of *Hyoscyamus* and *Borraginaceæ*, and in some other cases.

Ramification by partition of the *punctum vegetationis* and by the formation of lateral branches have been regarded as very different modes. Warming considers them as not

essentially distinct. In the vegetative part of the stem the formation of the leaves is the main object, and the buds do not arise till they have acquired a considerable size. In the region of inflorescence the formation of buds becomes of primary importance; they increase in vigour and gradually advance from a lateral position to a position on the summit of the stem near the median line.

It has been supposed that abnormal formations such as fasciations are due to a partition of the *punctum vegetationis*. Warming, therefore, studied the development of *Celosia cristata* and of *Brassica oleracea* var. *botrytis*. The first developes its inflorescence like a Composite, with the only difference that its receptacle is irregular and compressed, and the second by a very rapid formation of buds. But in neither was there any trace of a partition of the vegetative point.

The distinction of phyllomes from caulomes by morphologically and genetically distinct characters is impossible. They both arise from the peripheral tissues at a depth which varies with the size they subsequently attain; thus bracts arise very often in the first layer of the periblem, while caulomes hardly ever do so, but most usually in the third or fourth layers. A distinctive character, perhaps, consists in the fact that in the centre of phyllomes procambium cells originate very rapidly, and the tissue is consequently far from offering the same regularity as the plerome of young caulomes.

The majority of buds are axillary; this is so uniform that it has been regarded as the only normal one, and has led to the supposition that the buds in all ebracteate inflorescences arise from a partition of the *punctum vegetationis*. The causal nexus between the leaf and its axillary bud at present remains unexplained. In their origin they are always united at their base, and they may be, perhaps, regarded as forming a whole of which the two constituent portions have a different morphological character according to the role which they have to fill; it is sometimes one, sometimes the other part of the double organ which is developed, while in other cases both are in equilibrium.

7. *Perigynium of Carex.*—Dr. McNab and W. T. Thiselton Dyer contribute observations on this structure to the 'Journ. Linn. Soc.,' xiv, 152 and 154, which appear to prove that it is a foliar organ, consisting of a bract alternating with that which subtends the whole flower.

8. *Development of Buds of Malaxis.*—Prof. Dickie describes in the 'Journ. Linn. Soc.,' xiv, 180—182, the development of the buds on the leaves of *Malaxis*. "The bodies in question agree with the ovule in this: the nucleus appears

first, and the coat next in order—both, however, being produced by differentiation from the same mass of parenchyma." It is difficult to accept this view—unsupported as it is by similar facts—without further investigation.

9. *Ovule and Seed.*—i. In an elaborate paper ('Ann. des Sc. Nat.,' 5 sér., xix, 5) on the development of these structures in *Schrophulariaceæ, Solanaceæ, Boraginaceæ,* and *Labiatæ,* Chatin appears to have arrived at no general result of importance. He congratulates himself on having seen a pollen tube enter the micropyle of *Veronica Chamædrys.* Schacht long ago pointed out that this phenomenon might generally be demonstrated in *V. serpyllifolia,* when the corolla had just fallen.

ii. Dr. Hooker, in a paper in the 'Journ. Linn. Soc.,' xiv, 182-188, identifies the *Hydnora americana* of R. Brown with De Bary's *Prosopanche.* He confirms De Bary's observation of the ovules being actually buried in and confluent with the placental tissues.

iii. According to Warming (l. c., xvi and xxxv) ovules are most frequently metamorphosed caulomes. They originate beneath the first layer (*Euphorbia, Scrophularia*) of the periblem, sometimes in this layer itself (*Ranunculus acris*), or as buds on the base of foliar organs (*Salix*). The integuments of *Euphorbia* originate in a great measure in the dermatogen. Warming regards these as phyllomes and the nucleus as a caulome. The embryo-sac is sometimes formed of a cell of the first layer of periblem (*Scrophularia.*) In *Euphorbia* it appears to originate from the second layer.

PROCEEDINGS OF SOCIETIES.

Royal Microscopical Society.

February 4th, 1874.

This being the Annual General Meeting, the Officers and Council for the ensuing year were elected as follows, viz.—

President.—Charles Brooke, M.A., F.R.S.

Vice-Presidents. — Robert Braithwaite, M.D., F.L.S.; John Miller, L.R.C.P., F.L.S.; William Kitchen Parker, F.R.S.; Francis H. Wenham, C.E.

Treasurer.—John Ware Stephenson, F.R.A.S.

Secretaries.—Henry J. Slack, F.G.S.; Charles Stewart, M.R.C.S., F.L S.

Council.—James Bell, F.C.S.; Frank Crisp, LL.B. B.A.; William J. Gray, M.D.; John E. Ingpen, Esq.; Samuel J. McIntire, Esq.; Henry Lee, F.L.S.; William T. Loy, Esq.; Henry Lawson, M.D.; Henry Perigal, F.R.A.S.; Alfred Saunders, M.R.C.S.; Charles Tyler, F.L.S.; Thomas C. White, M.R.C.S.

The Annual Report of the Society was read, from which it appeared that nine Fellows had been elected during the past year, and five had died during the same period. Among the latter was Mr. Cornelius Varley, one of the founders of the Society, and, like his distinguished brother John Varley, well known as a water-colour painter. He contributed several papers to the 'Transactions' of the Society, and invented many improvements in the microscope. Mr. Varley died in his ninety-second year.

A new bye-law relating to the election of Corresponding Fellows was proposed and passed.

The President then delivered the annual address.

He stated that renewed application had been made to the Government for accommodation for the Society in Burlington House, but that the matter was still under consideration.

The President referred to some of the papers which had been published in the Journal of the Society, especially one by Dr. Pritchard, on the cochlea, read before the Medical Microscopical Society; Mr. Wenham's on a new formula for an object-glass, and some contributions by Dr. Royston-Pigott.

The President, having filled the office of scientific juror at the Vienna Exhibition, spoke of some of the microscopes and objectives there exhibited, singling out those of Hartnack for special com-

mendation, while others by Gundlach and Nachet were also described as good. None by English makers had come under his notice.

March 4th, 1874.

Charles Brooke, Esq., F.R.S., President, in the chair.

Mr. Alfred Saunders read a paper entitled "A Contribution towards a Knowledge of Appendicularia," in which he minutely described the appearance and structure of specimens found at Torquay and Weymouth. A paper by Dr. Royston-Pigott, F.R.S., entitled "A Note on the Verification of Structure by the Motion of Compressed Fluid," and another by the same author on "A Note on the President's Remarks on Dr. Pigott's Searcher for Aplanatic Images," were read.

The first paper gave an account of some appearances produced in the "beads" and other minute structures of certain microscopic objects by the movements and currents in the fluid produced by pressure applied to the covering glass. The objects were immersed in various fluids, such as Rangoon oil, glycerine containing chloride of gold in solution, &c., and pressure applied by the direct contact of the objective (a $\frac{1}{8}$ or $\frac{1}{6}$) with the cover glass. The method was chiefly applied to determine certain points in the structure of the Podura scale.

In his second paper Dr. Pigott gave an explanation of his 'aplanatic searcher,' which he defined as being a new expedient for balancing spherical and chromatic aberration, being on a large scale precisely what the adjusting screw collar of an objective is on a minute scale. The collar separates the front lens by thousandths of an inch. The searcher traverses inches.

April 1st, 1874.

F. H. Wenham, Esq., Vice-President, in the chair.

A paper by Dr. Anthony, "On the Structure of a Lepisma Scale," was read by the Secretary, &c.

Mr. Wenham made a communication on an instrument for excluding extraneous rays in measuring apertures of microscope object-glasses, and demonstrated his method to the Society.

Mr. S. J. McIntire read a "Note on a curious proboscis of an unknown Moth." The proboscis ended in a hard chitinous point, and was furnished with several formidable recurved spines, so as to be fitted, apparently, both for penetration and retention. The specimen came from Western Africa.

A "scientific evening" was held on April 15th, in the great Hall of King's College, when a number of interesting objects were exhibited.

Medical Microscopical Society.

20th March, 1874.

Staining with Aniline Dyes for Balsam Mounting.—Mr. George Gibbs read a paper on this subject, which he was first led to study from reading the following passage in Frey's 'The Microscope:' —" It is very unfortunate that alcohol soon extracts the colour [of aniline red], so that it is impossible to preserve the specimen in Canada balsam."

To obviate this inconvenience he tried a 2 per cent. solution of aniline in spirit, and then found that by staining sections that had been in spirit with this solution for three or four minutes, rinsing in spirit, and placing subsequently in oil of cloves, the colour was perfectly preserved when the specimen was mounted in Canada balsam.

Oil of cloves was preferable to turpentine, the latter at times precipitating the colouring matter; but should this occur, brushing with a camel's hair pencil would remove the deposit. Mr. Gibbs claimed three advantages for this method:—1st. Its cleanliness. 2nd. That one has the most perfect control over the depth of colour obtained by regulating the time of the subsequent washing in spirit. 3rd. That the colour is less trying to the eyes than that of carmine. Its selective power was greater than that of Frey's aqueous solution of aniline, the nerve-fibres of the spinal cord as well as the nuclei of cells being vividly brought out.

Staining with Picro-carminate of Ammonia.—The Secretary read Dr. E. Cresswell Baber's paper upon this subject, which is published *in extenso* in the present number of the Journal.

Dr. Matthews remarked that some tissues attract red rather than purple colours; thus nuclei generally were more easily stained by the former. Judson's dyes he had found useful. Referred to Frei's methods if employing pico-carmine; had obtained good results from first staining in carmine, and subsequently in a solution of picric acid. He had found Stevens' writing fluid a ready and useful stain for sections.

Mr. White had found a section of epithelioma stained with logwood, and then with picric acid, showed the yellow centres of the "birds' nests" described by Mr. Baber, while the surrounding parts were tinted by the hæmatoxylin. Had only used carmine and picric acid as separate solutions, but by this means had seen yellow channels of communication from one bird's nest to another.

Mr. Kesteven asked if aniline dyes were permanent.

Mr. Atkinson found that crystallized magenta, when first used for staining sections became blue, and then after a time disap-

peared; but mounting in one third per cent. of corrosive sublimate prevented this.

Mr. Schäfer had given up carmine because of its too brilliant colour, and always used logwood, which he found selective in property. He thought osmic acid better than picric carmine for nerve-tissues, and remarked that Dr. Sharpey had long ago used magenta for staining the axis cylinders of nerves.

Mr. Miller had found a solution of carmine and a 1 per cent. solution of picric acid in alcohol and water especially good for splenic and unstriped muscular fibres. He preferred carmine to logwood.

Mr. Groves, except in the case of nerve-structures, preferred logwood to carmine. The double staining of logwood and gold chloride was good for nerves and nuclei, and especially for such structures as frog's bladder.

Mr. Golding Bird mentioned Dr. Moxon's use of Stevens's writing fluid for staining nerve-structures, and mentioned a fact communicated to him by Dr. Malassez, of Paris, that aniline dissolved in spirit was especially good for studying ossification of cartilage; for it stained the cartilage but not the newly formed bone, while an aqueous solution of aniline stained the canaliculi and not the bone substance, but was not permanent like the alcoholic solution.

The President, in proposing a vote of thanks to the authors of the papers, which was duly accorded, remarked that more investigation was required on the subject of staining fluids, and recommended it as an object of special study that would certainly be productive of useful results.

Miliary Sclerosis.—Mr. W. B. Kesteven read a paper upon a form of grey degeneration occurring in the brain and spinal cord, and designated by Drs. Batty Tuke and Rutherford, "miliary sclerosis." The author showed examples of this lesion by sections and drawings. The change is associated with a wide range of diseases of the nervous centres. He enumerated as many as twenty morbid conditions in which he had met with the so-called miliary sclerosis. The essential characters of this lesion Mr. Kesteven showed to consist in the absence, in circumscribed patches, of the normal nerve-tissue, and its replacement by an altered and degenerate state of the neuroglia. The spots vary in size from $\frac{1}{50}$th in. to $\frac{1}{500}$th in. in diameter. Their physical characters were described in detail, and the author then proceeds to discuss the question of how this character was connected with previous symptoms, and whether it is possible that they could be the result of mere post-mortem changes. These questions, he submitted, were as yet unanswered. Judging from the great diversity of pathological conditions in which this degeneration is met with, he deemed the solution of the problem impossible, with our present amount of knowledge in neuro-pathology.

Dr. Payne asked whether Mr. Kesteven had found miliary

sclerosis in a spinal cord or brain otherwise quite healthy, and discussed the question as to whether the changes described might not be the commencement of secondary degenerations of nerves, as is seen to result from inactivity of a nerve arising from any cause, or of the wasting of certain nerve-fibres, that might go on to worse changes.

Mr. Schäfer took exception to the name as giving the idea of fibrous or cicatricial tissue, whereas what had been described was rather colloid in nature, for at times it could be stained intensely. He had seen miliary sclerosis in the brain of a supposed healthy dog that had been hardened in chromic acid, and from this he concluded that the alcohol used to prepare the specimens could not be the cause of the "sclerosis," as had been alleged, seeing that he had used none. As the disease followed no special tracts he considered it could not be simply degeneration of nerve-fibres.

Dr. Matthews asked whether coincident disease—as atheroma—of the vessels of the brain had been noticed.

The President had seen miliary sclerosis accompanied by calcareous change in the vessels, and in a case where death resulted from cerebral hæmorrhage; also in preparations of brain made by Dr. Crisp from the lower animals, and hardened in chromic acid.

Mr. Kesteven, in reply, considered the term sclerosis certainly more applicable to the cases where the disease occurs *en plâques*. There was nothing of fibrous nature in the condition he had been describing; still, Dr. Tuke had given the name originally. He did not consider the alteration colloid, though at first sight resembling it; nor had he noticed the change in connection with atheromatous vessels, though at times the bodies described were calcareous and gritty ("brain sand"). Agreed with Mr. Schäfer in not considering the condition as one of nerve-fibre degeneration, and was, in fact, still seeking an explanation.

18*th April*, 1874.

Diphtheria.—Dr. Greenfield read a paper which was founded upon the microscopical examination of specimens from five cases of diphtheria, and was illustrated by preparations. The author, in remarking upon the obscurity and doubt which still seemed to exist upon the origin and structure of the diphtheritic false membrane, stated his belief that this arose in part from the confusion in the nomenclature in common use, especially the fact that 'croupous' and 'diphtheritic' were terms used in different senses, clinically and histologically.

An examination of his cases showed in all, in the larynx and trachea, the mucous membrane surrounding the deeper tissues in a state of more or less intense inflammation of ordinary character, whilst the false membrane consisted for the most part of a

stratified network of a substance giving the reactions of fibrin, in the meshes of which were contained altered epithelial cells and corpuscles.

The amount of adhesion to the mucous membrane was various, but in no case did the exudation actually pass into its substance, although in some cases it appeared adherent by fibrinous bands to the papillæ.

After describing the views of Wagner and of other German pathologists, the author stated his belief that the false membrane consisted in part of a catarrhal process with modifications in the epithelium, and in part of a true fibrinous exudation. These views were supported by the comparative examination of specimens taken from cases in various stages.

In the pharynx the inflammatory process was stated to extend much deeper than in the trachea, and to be accompanied by a more rapid destruction of tissue. The false membrane was believed to consist in a larger measure of altered cells.

The question of the occurrence and importance of fungous growth in the mucous membrane was then described, and the author showed specimens from the pharynx containing numbers of minute fungus spores and a delicate mycelium deeply penetrating the inflamed mucous membrane. He had not, however, been able to find any similar appearance in the larynx or trachea of the same or other cases, and he considered it, therefore, still an open question how far the fungus was an accidental occurrence, and what was its relation to the disease.

The President, after proposing a vote of thanks to the author of the paper, stated his belief that fungous growths might be always found in the mucous membranes in certain low states of health, and considered a fungus in diphtheria an accidental rather than an essential occurrence. He could not agree with Dr. Oscar, who held that the disease was owing to the presence of fungus. He had examined more than one case of diphtheritic conjunctivitis, in which disease the exudation forms very rapidly, but had never found any fungus. The position of a vegetable parasite upon the body had much to do with its influence upon the disease it accompanied or of which it was the cause; hence some importance might be attached to the specimen shown, where the fungus was deep in the inflamed mucous membrane.

Dr. Bruce remarked that croup is generally defined as owing to a false membrane, on the removal of which healthy mucous membrane is left; this, however, the paper would disprove, since Dr. Greenfield had shown that not only the mucous and submucous tissues were at times reached in croup, but that even the tracheal rings might be in part destroyed. He had also noticed the small cavities or vacuoles described in the false membranes, and thought them owing to the exudation from the ducts of mucous glands. These spaces were at times filled with exudation cells. The mucous epithelium is not necessarily destroyed by the false membrane; it may sometimes be seen covered by the latter.

Exudation of fibrin would fully account for the false membrane upon the mucous membrane, without interfering with the epithelium covering the latter, through which wandering cells might easily pass; and a precedent for fibrinous exudation on a mucous surface might be found in croupous pneumonia.

Mr. Needham thought that, as pus could come from a serous, fibrin might from a mucous membrane.

Dr. Coupland thought the different layers in the false membrane showed a mixed origin; thus the surface of it was more coarsely fibrillated than the deeper parts, which were much finer, as though there had been first a catarrh, destroying the epithelium, and then fibrinous exudation last of all.

Mr. Stowers asked for a verification of the observation made, that the histological appearances in the angina form of scarlatina and in a blistered surface were those of diphtheria.

Mr. Miller referred to Rindfleisch's remark that the exudation in pharyngeal affections was more cellular and less fibrillated than in laryngeal; as well as to the existence of apertures in the basement membrane of the affected parts.

The President thought the non-homogeneity of the false membrane might be explained by the different ages of its component parts, and suggested that the fungi so commonly found in diphtheria might owe their presence to the open-mouthed mode of respiration in diphtheritic patients; in the two cases of diphtheritic conjunctivitis already mentioned the eyes had been kept constantly bandaged, and, as stated, no fungus had been found.

Dr. Greenfield, in reply, quoted German authority for the constant presence of fungus in diphtheria; and, since fungi in the kidney had also been described, they might serve to explain the renal complications so constantly present. The only way to get at a life-history of a false membrane was to examine in the same subject the patches in all stages of growth. He had done this, but had only found at first a catarrhal state, and later on pus-globules and fibrillation on the deeper surface of the membrane. The fibrinous exudation in pneumonia was no precedent for the same process in diphtheria, since the air-cells might be proved, and were by some thought to be, part of the lymphatic system. Epithelium in place would not allow fibrin to exude, but once destroy the former and then exudation was easy. Two theories existed with regard to the part played by fungi in diphtheria, one that they were its cause, the other only the cause of the rapid disintegration of the membrane; it was a subject still *sub judice*.

Numerous specimens in illustration of Dr. Greenfield's paper were exhibited, as well as others of new growths, and of the glandular stomach of the crow.

15*th May*, 1874.

Molluscum fibrosum (? *Cheloid*).—Dr. Pritchard mentioned the case of a negro, who for twenty years had been subject to a growth originating behind one ear, and gradually extending over nearly all the body. After death a portion of the skin with growth was forwarded to him (from America), as illustrating "Cheloid simulating *Molluscum fibrosum.*" Microscopically, the cutis vera was found hypertrophied; here and there masses of cells between the fibres of the areolar tisssue; epidermis much thickened, hair-follicles normal; papillæ had grown regularly and sideways, and not vertically as normal. He considered it simply a case of *Molluscum fibrosum*, not of Cheloid. Engravings of the patient, with specimens of the disease, were exhibited.

Mr. Needham thought the condition of the papillæ normal in the negro.

Perivascular Spaces in the Brain.—Mr. Kesteven read a paper on this subject, illustrated by drawings and specimens. These spaces had been considered normal structures, intended to relieve intracranial blood-pressure; but Mr. Kesteven had never seen them in a really healthy brain; had often noticed them associated with chronic cerebral mischief, and hence concluded they were owing to absorption of brain-substance by the irregular circulation that goes on in chronic disease, the vessels being at one time full, at another nearly empty. Though the mode of preparation in chromic acid might render these spaces more evident by the shrinking of the blood-vessel, he did not think it sufficient to account entirely for them. He could find in the perivascular spaces no resemblance to normal lymphatic structure, while Dr. Batty Tuke had now abandoned the idea that they denoted a healthy condition of brain. Dr. Pritchard considered them entirely owing to the mode of preparation in chromic acid; he had never found them in sections made by freezing the brain. Mr. Needham argued their belonging to the lymphatic system, though not, strictly speaking, "lymphatics." The President explained them in some cases by the giving way of the capillaries around which they were found; he had seen the brain-substance stained with hæmatin in their vicinity; hence an explanation, perhaps, for some of the anomalous convulsions of childhood. Thought proof was wanting of their connection with the lymphatic system. Mr. Toirard asked if in injected brains these spaces were seen, or were obliterated by the distension of the vessel. In reply, Mr. Golding Bird stated that he had never seen them in injected specimens. Mr. Groves asked if Mr. Kesteven had ever examined the spaces by staining with nitrate of silver? Mr. Kesteven, quoting Mr. Batty Tuke, stated that the spaces had been found in the lower animals (*e.g.* cats) after strangulation; and that, though the vessels thus remained full, a space could be seen beyond. He had never seen anything to warrant the supposition that they were owing to hæmorrhage. He knew of no anatomist

having traced these spaces into lymphatics; they had been injected by His by the puncture method.

Multiple Cystic Tumour of Breast.—A specimen of this, exhibited by Mr. Needham, seemed to show, from the excess of epithelium in the mammary tubules, and the epithelial infiltration of surrounding parts, at once a cystic, adenomatous, and cancerous nature. Mr. Needham founded his idea of cancer on the arrangement and not on the intrinsic form of the cells composing it.

Dublin Microscopical Club.

22nd January, 1874.

Hairs and Epidermis of Oxalis.—Dr. Moore showed hairs of a Cape species of *Oxalis*, studded, as is so common with most species of the genus, with transparent papillæ.—He also showed the epidermis of the lower surface of a leaf of *Oxalis fragrans*, which showed the cells filled with purple sap, amongst which were abundance of transparent stomata.

Notes on Bermuda Diatoms.—Rev. E. O'Meara showed some Diatoms from Bermudas in a collection made by Mr. Moseley, of the "Challenger" expedition, at the south-west bank, Bermudas, from a depth of thirty-one fathoms, 23rd April, 1873. This abounded with forms belonging to the genera *Rhabdonema*, *Isthmia*, *Podocystis*, *Grammatophora*, and *Cocconeis*. The *Isthmia*-form was similar in some respects to *I. enervis* (Ehr.), but it was considered by Mr. Kitton, of Norwich, to be identical with *S. minima* (Harvey et Bailey). Several specimens of *Grammatophora serpentina* (Ehr.) occurred, which were remarkable for the striation being much coarser and the internal spiral structure being longer and of greater tenuity than is usual with the forms of that species found commonly in our country. Some few specimens of *Navicula apis*, Ehr., *Surirella fastuosa*, Ehr., *Actinoptycus senarius*, Ehr., *Coscinodiscus radiatus*, Ehr., *Synedra robusta*, Ralfs, were met with, as also numerous specimens of *Cocconeis crebristriata*, Grev., *C. coronata*, *C. punctatissima*, Greville, and *C. fimbriata*, Ehr. Four specimens were found of a new species of *Navicula*, previously found in Ireland by Mr. O'Meara and named *N. Pfitzeriana*. There were also other forms requiring further study.

Sodium Chloride Crystals in presence of Urea.—Mr. B. Wills Richardson exhibited some crystals of sodium chloride which he obtained from a saturated solution of this salt to which a solution of urea had been added. The crystals were much modified in form by the presence of the urea; one very large (microscopic) rhombic dodecahedron attracted a good deal of attention, its form

being most perfect. The crystals were mounted in Klein's dammar fluid.

Trichomanes radicans.—Dr. McNab showed some preparations illustrative of the Indusia and Sporangia of this fern.

Structure of Spines of Strongylocentrotus lividus.—Mr. Mackintosh exhibited transverse section of a spine of *S. lividus*, showing the main mass of the spine to be composed of a structureless calcification of a pale yellowish colour, exhibiting striæ, the two most internal being the most distinct, the middle occupied by a network of the ordinary echinoid structure, and proceeding outwards from this to the deep but narrow furrows, which flute the outside of the spines, are a number (twenty-two) of rays which are also reticulated. One of these rays exhibited the peculiarity of bifurcating a short distance from the circumference, each prong going to a furrow, this ray was scarcely, if at all, larger than its fellows, and there was not the least appearance of asymmetry or irregularity in the ridge which its two subdivisions enclosed.

Beryl Crystals; sections exhibited.—Dr. Reynolds showed some sections of beryl crystals from Mourne Mountains, exhibiting a peculiar internal structure indicating a change of form during its apparently interrupted growth.

Head of Tænia tetragonocephalus, exhibited.—Prof. Macalister showed the head of *Tænia tetragonocephalus*, a parasite of the maned anteater, *Myrmecophaga jubata.*

On Structure of Lambay Porphyry.—Prof. Hull, F.R.S., exhibited two thin sections of Lambay Porphyry—one taken from the rock at Lambay Island, the other from the opposite coast of Portrane, north of Dublin. The examination of these under a low magnifying power of twenty-five diameters showed that the dark base was composed of felsitic material, more or less crystalline, containing large numbers of black crystalline grains of magnetite, together with a little chlorite. It was evident that the dark colour was due entirely to the presence of magnetite, and not to hornblende, as had sometimes been supposed. In this base were included large crystals of orthoclase, giving the rock the porphyritic structure. Some cells were seen to be lined with chlorite and magnetite arranged in peculiar stellate or feathery forms, whilst the interior was filled by calcite. The exhibition was accompanied by excellently drawn figures by Prof. Hull, illustrative of the structure of the rock.

Exhibition of a preparation of, and cursory remarks on, a seemingly new and problematic Rhizopod.—Mr. Archer showed a preparation in Beale's carmine fluid of a Rhizopodous form he had encountered in various places, but always exceedingly sparingly (he had hoped to show a recent example, but failed on this occasion to alight on one). This was quite globular, the inner greyish or slightly yellowish body-mass surrounded by a colourless hyaline, thick, doubly-contoured envelope, marked by sparingly scattered dots, which seemed to indicate so many tubular

openings in the same, as they appeared, on being transversely viewed, to form lines (or striæ) passing inwards in a radial direction. In the living state Mr. Archer had very rarely been able to see pseudopodia, and but extremely sparingly protruded; it must be assumed that these made their way outwards through the minute tubular perforations in the outer envelope. In the specimens now under view (there were two on the slide) he thought a nucleus or "capsule" could be readily enough perceived, but, contrary to almost universal experience in similar cases, it might be said to have taken no dye from the carmine solution. The chief action of the fluid seemed to be that the central body-mass became contracted and completely withdrawn from the outer envelope in an externally more or less "crumpled" manner, the outer envelope remaining unaltered, showing these were quite differentiated portions of the structure; indeed, in a few instances, now and again, the *empty*, colourless and hyaline wall, then almost glassy looking, had been met with, and still retaining its quite globular figure. The question becomes, to what existent genus could this be referred? Of course the genus *Astrodisculus* (Greeff) at once suggests itself; but two other forms, two or three examples only of which Mr. Archer had ever seen, and which he had *thought* must be referable to Greeff's *Astrodisculus*, did not agree with the present form in some particulars. Greeff, indeed, ascribes to his *Astrodisculus* a porous and siliceous envelope—those previously found by Mr. Archer, very like, if not truly (?) referable thereto, had *soft* envelopes (destroyed by sulphuric acid). As regards the present form the envelope doubtless appeared porous, but Mr. Archer had not yet met with examples sufficient to experiment satisfactorily with acids; he had more than once tried to treat this form with reagents, but *lost* the specimen in the effort (they often *will* vanish from sight out of sheer cross purposes!); he must, therefore, relegate it to the future, in hopes this form may again turn up, when he would claim for it once more some attention from the Club.

19*th February*, 1874.

Remarks on Hairs of Platycerium.—Dr. Moore exhibited the beautiful stellate hairs which closely cover the whole surface of *Platycerium grande.* These were mostly 9-rayed, and were seen to good effect when polarized. Dr. Moore observed that these hairs revealed to us an adaptability of a wonderful nature, enabling the plant not only to control too rapid transpiration from the fronds during dry weather, but, he believed, to imbibe moisture from the atmosphere as well. He knew that it was a disputed point amongst physiologists whether plants were able to imbibe moisture through their leaves; some experiments lately made tend to prove they have no such function, but botanists, whose testimony is valuable, including the late Dr. Lindley and Dr. Asa Gray, believe that plants have the power of imbibing moisture

through their leaves, aud with the latter he was much inclined to coucur, judging from *primâ facie* evidence, without having made special experiments on the subject. The beautiful hairs exhibited aided the plant, he thought, very materially to perform this function.

New form of Diaphoracephalus, exhibited.—Mr. Geoghegan showed a form of *Diaphoracephalus*, which appeared to be undescribed, and of which he was preparing an account.

Structure of tubercle of Oreaster tuberculatus.—Mr. Mackintosh presented a very successfully prepared transverse section of a tubercle of *Oreaster tuberculatus.* This showed three distinct regions—a central, in which the interspaces are large aud the solid rods anastomose irregularly in the middle, but become more definitely arranged according as the intermediate portion is reached; this part consists of small oval spaces, with the rods intersecting more or less at right angles, and exhibits no indication whatever of circular arrangement; the third, or cortical layer, consists of very small rounded spaces, which increase in number on the inner border, and a large quantity of interstitial substance with a finely crenulate external edge.

Problematic ovum-like cyst, exhibited.—Mr. Archer drew attention to the empty coat of a puzzling ovum-like cyst now and again very sparingly noticed by him, and from gatherings made in various parts of the country. This was smooth, ovate, stipitate, the stipes furnished with a small globose thickening under the body, the base of the stipes somewhat scutate, by which attached to foreign objects. The upper portion of the ovate case was seen to have been removed, as is usual (as one removes the top of egg to get at the contents), and this by a "clean" cut or suture, leaving the body-portion like an elegant vase borne aloft on its delicate stalk; the colour of the whole yellow. Most probably this was really the "shell" of the ovum of some creature, the truncate upper part representing where the upper, and much the smaller, portion of the wall had become removed on the young animal making its exit. But, if an ovum, to what could it belong? Perhaps others might be able to throw a light on the nature or identity of this pretty "vase," which has always, as yet, shown itself without an owner.

Triceratium Campeachianum and Navicula aspera, exhibited.—Rev. E. O'Meara presented two slides, kindly supplied by the Club's corresponding member F. Kitton, Esq., of Norwich, one containing *Triceratium Campeachianum*, Grunow, which Mr. Kitton considered a 10-angled variety of *T. favus*, the other containing beautifully mounted specimens of *Navicula aspera*, which Dr. Donkin regards as identical with *Stauroneis pulchella*, but which Mr. O'Meara was disposed to consider a distinct species, notwithstanding the striking resemblance of the striation.

Micrococcus prodigiosus (Ehr.), Cohn, *exhibited.*—Mr. Archer, referring to Professor Cohn's late interesting and valuable paper on Bacteria "Untersuchungen über Bacterien" (trans-

lated in abstract Q. J. M. S., 1873, pp. 156—163), exhibited examples of *Micrococcus* (Monas) *prodigiosus* (Ehr.), Cohn, which had occurred on some slices of raw ("diseased") potatoes which had been left lying under a bell-glass. He remarked on the points dwelt on by Cohn as regards the *Sphærobacteria* (Cohn), to which sub-group the curious production now shown belong, falling under the category of "Pigment Bacteria," on account of the remarkable colours evinced, not by the cells themselves, but apparently due to the matrix. These examples showed at first a blood-red colour, but more recently a deep brick-red, changing to a brown. Prof. Cohn's illustration (Q. J. M. S., Pl. V, fig. 1) gives the cells as if typically globular, in the present instance they were elliptic, say one third longer than broad (the longest scarcely $\frac{1}{5000}''$); the walls very delicate. These cells are described as colourless, but they appeared rather to evince that bluish hue characteristic of phycochrome, and in tint came very near some *Nostoc*-cells. It might be worthy of remark that, though the production flourished best on the potato-surface, a very good *crop* had become developed underneath the slice, covering the lower surface of a piece of *paper* on which the potato-slice lay; thus too nearly, if not quite, in the dark—that is to say, the paper (to some extent, however, macerated) was *between* the potato and the Micrococcus-stratum.

19*th March*, 1874.

Fern-scales, and a new Fish-trough, exhibited.—Mr. Porte showed a series of mounted preparations of fern-scales from various ferns, some, when polarised, were of singular beauty.— He also showed a new trough of his own design and construction for viewing the circulation of the blood in the tail of a minnow. This consisted of a glass plate about three inches square, having two narrow wedge-shaped pieces of tin, about a quarter of an inch thick, and tapering to a point, cemented to the plate near its middle and about half an inch apart; over these a slip of glass was cemented, thus enclosing a narrow wedge-shaped space, "tapering to nothing" below, and sealed all round except at the upper oblong opening into which the *fish* is dropped tail foremost.

Pinnularia cardinalis, very rare in Ireland, exhibited.—Rev. E. O'Meara showed a specimen of *Pinnularia cardinalis* from a pond near Armagh. This is of extremely rare occurrence in Ireland. Smith attributes it to the Lough Mourne deposit, but though he (Mr. O'Meara) had often searched for it there, he had never been fortunate enough to find it. In a peat deposit from Dromore, Co. Down, kindly supplied by Mr. Gray, of Belfast, the middle of a valve was discovered, but no perfect example had previously come under his observation.—Mr. O'Meara also showed examples of *Rhabdonema Torellii*, Cleve, "Diatoms of the Arctic Sea." The form occurred not unfrequently in some gatherings made at Spitzbergen by Rev. A. E. Eaton.

Remarks on Structure of Pits in Taxus.—Dr. McNab exhibited a section of yew, *Taxus baccata*, under a Gundlach $\frac{1}{12}$-objective, and pointed out that the central pore or pit of the bordered pits of the yew were not round as generally described, but were in most cases elongated. The examination of a number of sections shows that the form of the pits varies, being in some round, but in the majority more or less elongated; the openings in the two sides cross, and thus produce the seeming circular opening as seen with a low power. In these general characters the bordered pits of the yew agree with those of the Cycads and with the genus next Taxus, namely, *Salisburia*. In examining the pits a high power is required; and if the wood-cells are treated with the iodo-chloride of zinc solution, the opening can be very easily demonstrated.

Structure of spines of Astropyga radiata. — Mr. Mackintosh exhibited transverse sections of the spine of *Astropyga radiata*. The spines vary in length from $\frac{1}{2}''$ to $1\frac{1}{2}''$, are fusiform, elliptical, very strongly serrated, and pink-orange or green in colour. In section the central part is seen to be occupied by a reticulation with very wide interspaces, the solid rods of which unite at its outer part to form a ring, from which pass outwards a number of clavate rays of homogeneous structure, ending externally in ridges, which vary in their degree of prominence according to the part of the serration through which the section passes, and are joined to one another by two or three rather slender bars, the whole forming a structure remarkable for its lightness and fragility.

Villi from Stomach of Myrmecophaga jubata, exhibited.—Mr. Geoghegan exhibited a preparation showing villi from stomach of *Myrmecophaga jubata*.

A Black Micrococcus (Cohn), *exhibited, and cursory notes thereon.*—Mr. Archer showed examples of a form appertaining to the Sphærobacterian genus *Micrococcus*, Cohn, which in the mass appeared of a very *nearly black* colour. Referring to the exhibition at last meeting of *Micrococcus prodigiosus* (Ehr.), Cohn, occurring on slices of raw potato, now, for sake of comparison, again shown to the meeting, Mr. Archer mentioned that, when he noticed the occurrence of that singular production on the potatoes in question, he had soon after introduced under the bell-glass covering them two pieces of boiled potato, one of which he rubbed on the older raw piece bearing the *Micrococcus prodigiosus* so as to well *inoculate* it therewith—the other he left untouched. It was this second piece of boiled potato which had become covered by the "black" *Micrococcus*. A blue *Micrococcus* is recorded; many, it is true, might discern in the example now shown a bluish shade—in fact, it might be denominated a "blue-black" (like cloth). But on being placed under the microscope (say a $\frac{1}{4}''$, or, better, a $\frac{1}{8}''$), there was a very noticeable difference from *M. prodigiosus* (now placed under two microscopes side by side). In the latter the cells were comparatively long and narrow, elliptic, with a

faint outline; in the "black" form they were still elliptic, but relatively to their width much, and absolutely somewhat, shorter, and showed a *dark*, it might be said thick, outline. The latter, or "black" form, was more prone to show the cells arranged in such a position in twos or fours, as was indicative of recent self-division. Four could sometimes be seen in a plane, their inner surfaces of contact of a thinner appearance, flat and sub-rectangular within at the central common point of union. Both, under a high ($\frac{1}{8}''$) power, showed a hyaline, not deep, rather sharply marked, "halo" surrounding the cells, the former (*M. prodigiosus*) more noticeably. The latter showed a "molecular" motion much more vividly than the former; it need not be said that no other motion was evinced. In both forms the colouring substance showed imbedded therein a more dense, as if granular, body, posed in the former more towards one end of the cell, and very minute; in the latter more nearly central, by comparison considerably larger. To call this granular body in either a "nucleus" would, of course, be far too great a begging of the question. Mr. Archer had called the inner substance "colouring substance," for, as previously mentioned, it gave to the eye a very *Nostoc*-like hue. The colour of the mass seems thus to be due mainly, if not altogether, to the tenacious medium binding the cells into a common stratum, and it is, to a great extent, borrowed by any mycelioid filaments should they be present. This colour in the aggregate Prof. Cohn regards as being of "specific" value, or, to say the least, of "race" value; that is, as indicating forms or types, which, by a continuous heredity, run on and on, each, as it were, in its own groove. Prof. Cohn supposes that the fitful and rather isolated manner in which these productions seem to occur is explained by their "germs" being carried from one suitable *nidus* to another by the atmosphere. Here, however, were two forms quite distinguishable by the eye, either in the mass or under the microscope, occurring one on each of two pieces of the same potato; one of these forms Mr. Archer had "sown," the other "came there," and both were under the same bell-glass. The original (boiled) potato was in no way "diseased" (he knew from practical experience, indeed, it was excellent, having eaten the rest of it some days before at dinner; he would rather not venture on the remainder now!). Probabilities, he thought, were much in favour of Prof. Cohn's views, but Mr. Archer gave this little history *quantum valeat*.

MEMOIRS.

A Preliminary Account *of the* Development *of the* Elasmobranch Fishes.[1] By F. M. Balfour, B.A., Trinity College, Cambridge. (With Plates XIII, XIV, and XV.)

During the spring of the present year I was studying at the Zoological Station, founded by Dr. Dohrn at Naples, and entirely through its agency was supplied with several hundred eggs of various species of Dog-fish (Selachii)—a far larger number than any naturalist has previously had an opportunity of studying. The majority of the eggs belonged to an oviparous species of *Mustelus*, but in addition to these I had a considerable number of eggs of two or three species of *Scyllium*, and some of the Torpedo. Moreover, since my return to England, Professor Huxley has most liberally given me several embryos of *Scyllium stellare* in a more advanced condition than I ever had at Naples, which have enabled me to fill up some lacunæ in my observations.

On many points my investigations are not yet finished, but I have already made out a number of facts which I venture to believe will add to our knowledge of vertebrate embryology; and since it is probable that some time will elapse before I am able to give a complete account of my investigations, I have thought it worth while preparing a preliminary paper in which I have briefly, but I hope in an intelligible manner, described some of the more interesting points in the development of the Elasmobranchii. The first-named species (*Mustelus* sp.?) was alone used for the early stages, for the later ones I have also employed the other species, whose eggs I have had; but as far as I have seen at present, the differences between the various species in early embryonic life are of no importance.

Without further preface I will pass on to my investigations.

The Egg-shell.

In the eggs of all the species of Dog-fishes which I have examined the yolk lies nearest that end of the quadrilateral

[1] Read in Section D, at the Meeting of the British Association at Belfast.

shell which has the shortest pair of strings for attachment This is probably due to the shape of the cavity of the shell, and is certainly not due to the presence of any structures similar to chalazæ.

The Yolk.

The yolk is not enclosed in any membrane comparable to the vitelline membrane of Birds, but lies freely in a viscid albumen which fills up the egg-capsule. It possesses considerable consistency, so that it can be removed into a basin, in spite of the absence of a vitelline membrane, without falling to pieces. This consistency is not merely a property of the yolk-sphere as a whole, but is shared by every individual part of it.

With the exception of some finely granular matter around the blastoderm, the yolk consists of rather small, elliptical, highly refracting bodies, whose shape is very characteristic and renders them easily recognizable. A number of striæ like those of muscle are generally visible on most of the spherules, which give them the appearance of being in the act of breaking up into a series of discs; but whether these striæ are normal, or produced by the action of water I have not determined.

Position of the Blastoderm.

The blastoderm is always situated, immediately after impregnation, near the pole of the yolk which lies close to the end of the egg-capsule. Its position varies a little in the different species and is not quite constant in different eggs of the same species. But this general situation is quite invariable.

Segmentation.

In a fresh specimen, in which segmentation has only just commenced, the blastoderm or germinal disc appears as a circular disc, distinctly marked off by a dark line from the rest of the yolk. This line, as is proved by sections, is the indication of a very shallow groove. The appearance of sharpness of distinction between the germ and the yolk is further intensified by their marked difference of colour, the germ itself being usually of a darker shade than the remainder of the yolk; while around its edge, and apparently sharply separated from it by the groove before mentioned, is a ring of a different shade which graduates at its outer border into the normal shade of the yolk.

These appearances are proved by transverse sections to be

deceptive. There is no sharp line either at the sides or below separating the blastoderm from the yolk. In the passage between the fine granular matter of the germ to the coarser yolk-spheres every intermediate size of granule is present; and, though the space between the two is rather narrow, in no sense of the word can there be said to be any break or line between them.

This gradual passage stands in marked contrast with what we shall find to be the case at the close of the segmentation. In the youngest egg which I had, the germinal disc was already divided into four segments by two furrows at right angles. These furrows, however, did not reach its edge; and from my sections I have found that they were not cut off below by any horizontal furrow. So that the four segments were continuous below with the remainder of the germ without a break.

In the next youngest specimen which I had, there were already present eighteen segments, somewhat irregular in size, but which might roughly be divided into an outer ring of larger spheres, separated, as it were, by a circular furrow from an inner series of smaller segments. The furrows in this case reached quite to the edge of the germinal disc.

The remarks I made in reference to the earlier specimen about the separation of the germ from the yolk apply in every particular to the present one. The external limit of the blastoderm was not defined by a true furrow, and the segmentation furrows still ended below without meeting any horizontal furrows, so that the blastoderm was not yet separated by any line from the remainder of the yolk, and the segments of which it was composed were still only circumscribed upon five sides. In this particular the segmentation in these animals differs materially from that in the Bird, where the horizontal furrows appear very early.

In each segment a nucleus was generally to be seen in sections. I will, however, reserve my remarks upon the nature of the nuclei till I discuss the nuclei of the blastoderm as a whole.

For some little time the peripheral segments continue larger than the more central ones, but this difference of size becomes less and less marked, and before the segments have become too small to be seen with the simple microscope, their size appears to be uniform over the whole surface of the blastoderm.

In blastoderms somewhat older than the one last described the segments have already become completely separate masses, and each of them already possesses a distinct nucleus. They

form a layer one or two segments deep. The limits of the blastoderm are not, however, defined by the already completed segments, but outside these new segments continue to be formed around nuclei which appear in the yolk. At this stage there is, therefore, no line of demarcation between the germ and the yolk, but the yolk is being bored into, so to speak, by a continuous process of fresh segmentation.

The further segmentation of the already existing spheres, and the formation of new ones from the yolk below and to the sides continues till the central cells acquire their final size, the peripheral ones being still large and undefined towards the yolk. These also soon reach the final size, and the blastoderm then becomes rounded off towards the yolk and sharply separated from it.

The Nuclei of the Yolk.

Intimately connected with the segmentation is the appearance and history of a number of nuclei which arise in the yolk surrounding the blastoderm.

When the horizontal furrows appear which first separate the blastoderm from the yolk, the separation does not occur along the line of passage from the fine to the coarse yolk, but in the former at some distance from this line.

The blastoderm thus rests upon a mass of finely granular material, from which, however, it is sharply separated. At this time there appear in this finely granular material a number of nuclei of a rather peculiar character.

They vary immensely in size—from that of an ordinary nucleus to a size greater than the largest blastoderm-cell.

In Pl. XIII, fig. 1, *n*, is shown their distribution in this finely granular matter and their variation in size. But whatever may be their size, they always possess the same characteristic structure. This is shown in Pl. XIII, figs. 1 and 2, *n*.

They are rather irregular in shape, with a tendency when small to be roundish, and are divided by a number of lines into distinct areas, in each of which a nucleolus is to be seen. The lines dividing them into these areas have a tendency (in the smaller specimens) to radiate from the centre, as shown in Pl. XIII, fig. 1.

These nuclei colour red with hæmatoxylin and carmine and brown with osmic acid, while the nucleoli or granules contained in the areas also colour *very intensely* with all the three above-named reagents.

With such a peculiar structure, in favorable specimens these nuclei are very easily recognised, and their distribution

can be determined without difficulty. They are not present alone in the finely granular yolk, but also in the coarsely granular yolk adjoining it. They form very often a special row, sometimes still more markedly than in Pl. XIII, fig. 1, along the floor of the segmentation cavity. They are not, however, found alone in the yolk. All the blastoderm-cells in the earlier stages possess precisely similar nuclei! From the appearance of the first nucleus in a segmentation-sphere till a comparatively late period in development, every nucleus which can be distinctly seen is found to be of this character. In Pl. XIII, fig. 2, this is very distinctly shown.

(1) We have, then, nuclei of this very peculiar character scattered through the subgerminal granular matter, and also universally present in the cells of the blastoderm. (2) These nuclei are distributed in a special manner under the floor of the segmentation cavity on which new cells are continually appearing. Putting these two facts together, there would be the strongest presumption that these nuclei do actually become the nuclei of cells which enter the blastoderm, and such is actually the case. In my account of a segmentation I have, indeed, already mentioned this, and I will return to it, but before doing so will enter more fully into the distribution of these nuclei in the yolk.

They appear in small numbers around the blastoderm at the close of segmentation, and round each one of them there may at this time be seen in osmic acid specimens, and with high powers, a fine network similar to but finer than that represented in Pl. XIII, fig. 2, *n y*. This network cannot, as a general rule, be traced far into the yolk, but in some exceptionally thin specimens it may be seen in any part of the fine granular yolk around the blastoderm, the meshes of the network being, however, considerably coarser between than around the nuclei. This network may be seen in the fine granular material around the germ till the latest period of which I have yet cut sections of the blastoderm. In the later specimens, indeed, it is very much more distinctly seen than in the earlier, owing to the fact that in parts of the blastoderm, especially under the embryo, the yolk-granules have disappeared partly or entirely, leaving only this fine network with the nuclei in it.

A specimen of this kind is represented in Pl. XIII, fig. 2, *n y*, where the meshes of the network are seen to be finer immediately around the nuclei, and coarser in the intervals. The specimen further shows in the clearest manner that this network is *not* divided into areas, each representing a cell and each containing a nucleus. I do not know to what

extent this network extends into the yolk. I have never yet seen the limits of it, though it is very common to see the coarsest yolk-granules lying in its meshes. Some of these are shown in Pl. XIII, fig. 2, *y k*.

This network of lines[1] (probably bubbles) is characteristic of many cells, especially ova. We are, therefore, forced to believe that the fine granular and probably coarser granular yolk of this meroblastic egg consists of an active organized basis with passive yolk-spheres imbedded in it. The organized basis is especially concentrated at the germinal pole of the egg, but becomes less and less in quantity, as compared with the yoke-spheres, the further we depart from this.

Admitting, as I think it is necessary to do, the organized condition of the whole yolk sphere, there are two possible views as to its nature. We may either take the view that it is one gigantic cell, the ovum, which has grown at the expense of the other cells of the egg-follicle, and that these cells in becoming absorbed have completely lost their individuality; or we may look upon the true formative yolk (as far as we can separate it from the remainder of the food yolk) as the remains of one cell (the primitive ovum), and the remainder of the yolk as a body formed from the coalescence of the other cells of the egg-follicle, which is adherent to, but has not coalesced with, the primitive ovum, the cells in this case not having completely lost their individuality; and to these cells, the nuclei, I have found, must be supposed to belong.

The former view I think, for many reasons, the most probable. The share of these nuclei in the segmentation, and the presence of similar nuclei in the cells of the germ, both support it, and are at the same time difficulties in the way of the other view. Leaving this question which cannot be discussed fully in a preliminary paper like the present one, I will pass on to another important question, viz.—

How do these nuclei originate? Are they formed by the division of the pre-existing nuclei, or by an independent formation. It must be admitted that many specimens are strongly in favour of the view that they increase by division. In the first place, they are often seen "two together;" examples of this will be seen in Pl. XIII, fig. 1. In the second place, I have found several specimens in which five or six appear close together, which look very much as if there had been an actual division into six nuclei. It is, however, possible in this case that the nuclei are really connected below and only

[1] The interpretation of this network is entirely due to Dr. Kleinenberg, who suggested it to me on my showing him a number of specimens exhibiting the nuclei and network.

appear separate, owing to the crenate form of the mass. Against this may be put the fact that the division of a nucleus is by no means so common as has been sometimes supposed, that in segmentation it has very rarely been observed that the nucleus of a sphere first divides,[1] and that then segmentation takes place, but segmentation generally occurs and then a new nucleus arises in each of the newly formed spheres. Such nuclei as I have described are rare; they have, however, been observed in the egg of a *Nephelis* (one of the Leeches), and have in that case been said to divide. Dr. Kleinenberg, however, by following a single egg through the whole course of its development, has satisfied himself that this is not the case, and that, further, these nuclei in Nephelis never form the nuclei of newly developing cells.

I must leave it an open question, and indeed one which can hardly be solved from sections, whether these nuclei arise freely or increase by division, but I am inclined to believe that both processes may possibly take place. In any case their division does not appear to determine the segmentation or segregation of the protoplasm around them.

As was mentioned in my account of the segmentation, these nuclei first appear during that process, and become the nuclei of the freshly formed segmentation spheres. At the close of segmentation a few of them are still to be seen around the blastoderm, but they are not very numerous.

From this period they rapidly increase in number, up to the commencement of the formation of the embryo as a body distinct from the germ. Though before this period they probably become the nuclei of veritable cells which enter the germ, it is not till this period, when the growth of the blastoderm becomes very rapid and it commences to spread over the yolk, that these new cells are formed in large numbers. I have many specimens of this age which show the formation of these new cells with great clearness. This is most distinctly to be seen immediately below the embryo, where the yolk-spherules are few in number. At the opposite end of the blastoderm I believe that more of these cells are formed, but, owing to the presence of numerous yolk-spherules, it is much more difficult to make certain of this.

[1] Kowalevsky ("Beitrage zur Entwickelungsgeschichte der Holothurien," 'Mémoirs de l'Ac. Imp. de St. Petersbourg,' vii ser., vol. xi, 1867) describes the division of nuclei during segmentation in the Holothurians, and other observers have described it elsewhere.

As to the final destination of these cells, my observations are not yet completed. Probably a large number of them are concerned in the formation of the vascular system, but I will give reasons later on for believing that some of them are concerned in the formation of the walls of the digestive canal and of other parts.

I will conclude my account of these nuclei by briefly summarizing the points I have arrived at in reference to them.

A portion, or more probably the whole, of the *yolk* of the Dog-fish consists of *organized material,* in which nuclei appear and increase either by *division* or by a process of *independent* formation, and a great number of these subsequently become the nuclei of cells formed around them, frequently at a distance from the germ, which then travel up and enter it.

The formation of cells in the yolk, apart from the general process of segmentation, has been recognised by many observers. Kupffer ('Archiv. für Micr. Anat.,' Bd. iv, 1868) and Owsjannikow ("Entwickelung der Coregonus," 'Bulletin der Akad. St. Petersburgh,' vol. xix) in osseous fishes,[1] Ray Lankester ('Annals and Mag. of Nat. History,' vol. xi, 1873, p. 81) in Cephalopoda, Götte ('Archiv für Micr. Anat.,' vol. x) in the chick, have all described a new formation of cells from the so-called food-yolk. The organized nature of the whole or part of this, previous to the formation of the cells from it, has not, however, as a rule, been distinctly recognised. In the majority of cases, as, for instance, in Loligo, the nucleus is not the first thing to be formed, but a plastide is first formed, in which a nucleus subsequently makes its appearance.

Formation of the Layers.

Leaving these nuclei, I will now pass on to the formation of the layers.

At the close of segmentation the surface of the blastoderm is composed of cells of a uniform size, which, however, are too small to be seen by the aid of the simple microscope.

The cells of this uppermost layer are somewhat columnar,

[1] Götte, at the end of a paper on "The Development of the Layers in the Chick" ('Archiv. für Micr. Anat.,' vol. x, 1873, p. 196), mentions that the so-called cells in Osseous fishes which Œllacher states to have migrated into the yolk, and which are clearly the same as those mentioned by Owsjannikow, are really not *cells,* but large *nuclei.* If this statement is correct the phenomena in Osseous fishes are precisely the same as those I have described in the Dog-fish.

and can be distinguished from the remainder of the cells of the blastoderm as a separate layer. This layer forms the epiblast; and the Dog-fish agree with Birds, Batrachians, and Osseous fish in the very early differentiation of it.

The remainder of the cells of the blastoderm form a mass, many cells deep, in which it is impossible as yet or till a very considerably later period to distinguish two layers. They may be called the *lower layer cells.* Some of them near the edge of this mass are still considerably larger than the rest, but they are, as a whole, of a fairly uniform size. Their nuclei are of the same character as the nuclei in the yolk.

There is one point to be noticed in the shape of the blastoderm as a whole. It is unsymmetrical, and a much larger number of its cells are found collected at one end than at the other. This absence of symmetry is found in all sections which are cut parallel to the long axis of the egg-capsule. The thicker end is the region where the embryo will subsequently appear.

This very early appearance of distinction in the blastoderm between the end at which the embryo will appear, and the non-embryonic end is important, especially as showing the affinity of the modes of development of Osseous fishes and the Elasmobranchii. Oellacher (' Zeitschrift für Wiss. Zoologie,' vol. xxxiii, 1873) has shown, and, though differing from him on many other points, on this point Götte (' Arch. für Micr. Anat.,' vol. ix, 1873) agrees with him, that a similar absence of symmetry by which the embryonic end of the germ -is marked off, occurs almost immediately after the end of segmentation in Osseous fishes. In the early stages of development there are a number of remarkable points of agreement between the Osseous fish and the Dog-fish, combined with a number of equally remarkable points of difference. Some of these I shall point out as I proceed with my description.

The embryonic end of the germ is always the one which points towards the pole of the yolk farthest removed from the egg-capsule.

The germ grows, but not very rapidly, and without otherwise undergoing any very appreciable change, for some time.

The growth at these early periods appears to be particularly slow, especially when compared with the rapid manner in which some of the later stages of the development are passed through.

The next important change which occurs is the formation of the so-called " segmentation cavity."

This forms a very marked feature throughout the early

stages. It appears, however, to have somewhat different relations to the blastoderm than the homologous structure in other vertebrates. In its earliest stage which I have observed, it appears as a small cavity in the centre of the lower layer cells. This grows rapidly, and its roof becomes composed of epiblast and only a thin lining of "*lower layer*" cells, while its floor is formed by the yolk (Pl. XIII, fig. 3, *s c*). In the next and third stage (Pl. XIII, fig. 4, *s c*) its floor is formed by a thin layer of cells, its roof remaining as before. It has, however, become a less conspicuous formation than it was; and in the last (fourth) stage in which it can be distinguished it is very inconspicuous, and almost filled up by cells.

What I have called the second stage corresponds to a period in which no trace of the embryo is to be seen. In the third stage the embryonic end of the blastoderm projects outwards to form a structure which I shall speak of as the "embryonic rim," and in the fourth and last stage a distinct medullary groove is formed. For a considerable period during the second stage the segmentation cavity remains of about the same size; during the third stage it begins to be encroached upon and becomes smaller, both absolutely, and relatively to the increased size of the germ.

The segmentation cavity of the Dog-fish most nearly agrees with that of Osseous fishes in its mode of formation and relation to the embryo.

Dog-fish resemble Osseous fish in the fact that their embryos are entirely formed from a portion of the germ which does not form part of the roof of the segmentation cavity, so that the cells forming the roof of the segmentation cavity take *no share* at any time in the formation of their embryos. They further agree with Osseous fish (always supposing that the descriptions of Oellacher, loc. cit., and Götte, 'Archiv für Micr. Anat.,' Bd. ix, are correct) in the floor of the segmentation cavity being formed at one period by yolk. Together with these points of similarity there are some important differences.

(1) The segmentation cavity in the Osseous fish from the first arises as a cavity between the yolk and the blastoderm, and its floor is never at any period covered with cells. In the Dog-fish, as we have said above, both in the earlier and later periods the floor is covered with cells.

(2) The roof in the Dog-fish is *invariably* formed by the epiblast and a row of flattened lower layer cells.

According to both Götte and Oellacher the roof of the segmentation cavity in Osseous fishes is in the earlier stages

formed *alone* of the two layers which correspond with the single layer forming the epiblast in the Dog-fish. In Osseous fishes it is very difficult to distinguish the various layers, owing to the similarity of their component cells. In Dog-fish this is very easy, owing to the great distinctness of the epiblast, and it appears to me, on this account, very probable that the two above-named observers may be in error as to the constitution of its roof in the Osseous fish. With both the Bird and the Frog the segmentation cavity of the Dog-fish has some points of agreement, and some points of difference, but it would take me too far from my present subject to discuss them.

When the segmentation cavity is first formed, no great changes have taken place in the cells forming the blastoderm. The upper layer—the *epiblast*—is composed of a single layer of columnar cells, and the remainder of the cells of blastoderm, forming the lower layer, are of a fairly uniform size, and polygonal from mutual pressure. The whole edge of the blastoderm is thickened, but this thickening is especially marked at its embryonic end.

This thickened edge of the blastoderm is still more conspicuous in the next and second stage (Pl. XIII, fig. 3).

In the second stage the chief points of progress, in addition to the increased thickness of the edge of the blastoderm, are—

(1) The increased thickness and distinctness of the epiplast, caused by its cells becoming more columnar, though it remains as a one-cell-thick layer.

(2) The disappearance of the cells from the floor of the segmentation cavity.

The lower layer cells have undergone no important changes, and the blastoderm has increased very little if at all in size.

From Pl. XIII, fig. 3, it is seen that there is a far larger collection of cells at the embryonic than at the opposite end.

Passing over some rather unimportant stages, I will come to the next important one.

The general features of this (the third) stage in a surface view are—

(1) The increase in size of the blastoderm.

(2) The diminution in size of the segmentation cavity, both relatively and absolutely.

(3) The appearance of a portion of the blastoderm projecting beyond the rest over the yolk. This projecting rim extends for nearly half the circumference of the yolk, but is

most marked at the point where the embryo will shortly appear. I will call it the "embryonic rim."

These points are still better seen from sections than from surface views, and will be gathered at once from an inspection of Pl. XIII, fig. 4.

The epiblast has become still more columnar, and is markedly thicker in the region where the embryo will appear. But its most remarkable feature is that at the outer edge of the "embryonic rim" (*e r*) it turns round and becomes continuous with the lower layer cells. This feature is most important, and involves some peculiar modifications in the development. I will, however, reserve a discussion of its meaning till the next stage.

The only other important feature of this stage is the appearance of a layer of cells on the floor of the segmentation cavity.

Does this layer come from an ingrowth from the thickened edge of the blastoderm, or does it arise from the formation of new cells in the yolk?

It is almost impossible to answer this question with certainty. The following facts, however, make me believe that the newly formed cells do play an important part in the the formation of this layer.

(1) The presence at an earlier date of almost a row of nuclei under the floor of the segmentation cavity (Pl. XIII, fig. 1).

(2) The presence on the floor of the cavity of such large cells as those represented in fig. 1, *b d*, cells which are very different, as far as the size and granules are concerned, from the remainder of the cells of the blastoderm.

On the other hand, from this as well as other sections, I have satisfied myself that there is a distinct ingrowth of cells from the embryonic swelling. It is therefore most probable that both these processes, viz. a fresh formation and an ingrowth, have a share in the formation of the layer of cells on the floor of the segmentation cavity.

In the next stage we find the embryo rising up as a distinct body from the blastoderm, and I shall in future speak of the body, which now becomes distinct as the embryo. It corresponds with what Kupffer (loc. cit.) in his paper on the "Osseous Fishes" has called the "embryonic keel." This starting-point for speaking of the embryo as a distinct body is purely arbitrary and one merely of convenience. If I wished to fix more correctly upon a period which could be spoken of as marking the commencing formation of the embryo, I should select the time when structures

first appear to mark out the portion of the germ from which the embryo becomes formed; this period would be in the Elasmobranchii, as in the Osseous fish, at the termination of segmentation, when the want of symmetry between the embryonic end of the germ and the opposite end first appears.

I described in the last stage the formation of the "embryonic rim." It is in the middle point of this, where it projects most, that the development of the embryo takes place. There appear two parallel folds extending from the edge of the blastoderm towards the centre, and cut off at their central end by another transverse fold. These three folds raise up, between them, a flat broadish ridge, "*the embryo*" (Pl. XIV, fig. 5). The head end of the embryo is the end nearest the centre of the blastoderm, the tail end being the one formed by its (the blastoderm's) edge.

Almost from its first appearance this ridge acquires a shallow groove—the medullary groove (Pl. XIV, fig. 5, *m g*) —along its middle line, where the epiblast and hypoblast are in absolute contact (*vide* fig. 6 *a*, 7 *a*, 7 *b*, &c.), and where the mesoblast (which is already formed by this stage) is totally absent. This groove ends abruptly a little before the front end of the embryo, and is deepest in the middle and wide and shallow behind.

On each side of it is a plate of mesoblast equivalent to the combined vertebral and lateral plates of the Chick. These, though they cannot be considered as entirely the cause of the medullary groove, may perhaps help to make it deeper. In the parts of the germ outside the embryo the mesoblast is again totally absent, or, more correctly, we might say that outside the embryo the *lower layer cells* do not become differentiated into hypoblast and mesoblast, and remain continuous only with the lower of the two layers into which the *lower layer cells* become differentiated in the body of embryo. This state of things is not really very different from what we find in the Chick. Here outside the embryo (*i. e.* in the opaque area) there is a layer of cells in which no differentiation into hypoblast and mesoblast takes place, but the layer remains continuous rather with the mesoblast than the hypoblast.

There is one peculiarity in the formation of the mesoblast which I wish to call attention to, *i. e.* its formation as two lateral masses, one on each side of the middle line, but not continuous across this line (*vide* figs. 6 *a* and 6 *b*, and 7 *a* and 7 *b*). Whether this remarkable condition is the most primitive, *i. e.* whether, when in the stage before this the mesoblast

is first formed, it is only on each side of the middle line that the differentiation of the lower layer cells into hypoblast and mesoblast takes place, I do not certainly know, but it is undoubtedly a very early condition of the mesoblast. The condition of the mesoblast as two plates, one on each side of the neural canal, is precisely similar to its embryonic condition in many of the Vermes, *e. g. Euaxes* and *Lumbricus*. In these there are two plates of mesoblast, one on each side of the nervous cord, which are known as the *Germinal streaks* (Keimstreifen) (*vide* Kowalevsky Würmern u. Arthropoden; Mém. de l'Acad. Imp. St. Petersbourg, 1871).

From longitudinal sections I have found that the segmentation cavity has ceased by this stage to have any distinct existence, but that the whole space between the epiblast and the yolk is filled up with a mass of elongated cells, which probably are solely concerned in the formation of the vascular system. The thickened posterior edge of the blastoderm is still visible.

At the embryonic end of the blastoderm, as I pointed out in an earlier stage, the epiblast and the lower layer cells are perfectly continuous.

Where they join the epiblast, the *lower layer cells* become distinctly divided, and this division commenced even in the earlier stage, into two layers; a lower one, more directly continuous with the epiblast, consisting of cells somewhat resembling the epiblast-cells, and an upper one of more flattened cells (Pl. XIII, fig. 4, *m*). The first of these forms the hypoblast, and the latter the mesoblast. They are indicated by *hy* and *m* in the figures. The hypoblast, as I said before, remains continuous with the whole of the rest of lower layer cells of the blastoderm (*vide* fig. 7 *b*). This division into hypoblast and mesoblast commences at the earlier stage, but becomes much more marked during this one.

In describing the formation of the hypoblast and mesoblast in this way I have assumed that they are formed out of the large mass of lower layer cells which underlie the epiblast at the embryonic end of the blastoderm. But there is another and, in some ways, rather a tempting view, viz. to suppose that the epiblast, where it becomes continuous with the hypoblast, in reality becomes involuted, and that from this involuted epiblast are formed the whole mesoblast and hypoblast.

In this case we would be compelled to suppose that the mass of lower layer cells which forms the embryonic swelling is used as food for the growth of the involuted epiblast, or

else employed solely in the growth over the yolk of the non-embryonic portion of the blastoderm; but the latter possibility does not seem compatible with my sections.

I do not believe that it is possible, from the examination of sections alone, to decide which of these two views (viz. whether the epiblast is involuted, or whether it becomes merely continuous with the lower layer cells) is the true one. The question must be decided from other considerations.

The following ones have induced me to take the view that there is no involution, but that the mesoblast and hypoblast are formed from the lower layer cells.

(1) That it would be rather surprising to find the mass of lower layer cells which forms the "embryo swelling" playing no part in the formation of embryo.

(2) That the view that it is the lower layer cells from which the hypoblast and mesoblast are derived agrees with the mode of formation of these two layers in the Bird, and also in the Frog; since although, in the latter animal, there is an involution, this is not of the epiblast, but of the larger cells of lower pole of the yolk, which in part correspond with what I have called the lower layer cells in the Dog-fish.

If the view be accepted that it is from the lower layer cells that the hypoblast and mesoblast are formed, it becomes necessary to explain what the continuity of the hypoblast with the epiblast means.

The explanation of this is, I believe, the keystone to the whole position. The vertebrates may be divided as to their early development into two classes, viz. those with *holoblastic ova,* in which the digestive canal is formed by an *involution* with the presence of an "*anus of Rusconi.*"

This class includes "Amphioxus," the "Lamprey," the "Sturgeon," and "Batrachians."

The second class are those with *meroblastic ova* and no *anus of Rusconi,* and with an alimentary canal formed by the infolding of the sheet of hypoblast, the digestive canal remaining in communication with the food-yolk for the greater part of embryonic life by an umbilical canal.

This class includes the "Elasmobranchii," "Osseous fish," "Reptiles," and "Aves."

The mode of formation of the alimentary canal in the first class is clearly the more primitive; and it is equally clear that its mode of formation in the second class is an adaptation due to the presence of the large quantity of food-yolk.

In the Dog-fish I believe that we can see, to a certain

extent, how the change from the one to the other of these modes of development of the alimentary canal took place.

In all the members of the first class, viz. "*Amphioxus*," the "Lamprey," the "Sturgeon," and the "Batrachians," the epiblast becomes continuous with the hypoblast at the so-called "anus of Rusconi," and the alimentary canal, potentially in all and actually in the Sturgeon (*vide* Kowalevsky, Owsjannikow, and Wagner, 'Bulletin der Acad. d. St. Petersbourg,' vol. xiv, 1870, "Entwicklung der Störe"), communicates freely at its extreme hind end with the neural canal. The same is the case in the Dog-fish. In these, when the folding in to form the alimentary canal on the one hand, and the neural on the other, takes place, the two foldings unite at the corner, where the epiblast and hypoblast are in continuity, and place the two tubes, the neural and alimentary, in free communication with each other.[1]

There is, however, nothing corresponding with the "anus of Rusconi," which merely indicates the position of the involution of the digestive canal, and subsequently completely closes up, though it nearly coincides in position with the true anus in the Batrachians, &c.

This remarkable point of similarity between the Dog-fish's development and the normal mode of development in the first class (the holoblastic) of vertebrates, renders it quite clear that the continuity of the epiblast and hypoblast in the Dog-fish is really the remnant of a more primitive condition, when the alimentary canal was formed by an involution. Besides the continuity between neural and alimentary canals, we have other remnants of the primitive involution. Amongst these the most marked is the formation of the embryonic rim, which is nothing less than the commencement of an involution. Its form is due to the flattened, sheet-like condition of the germ. In the mode in which the alimentary canal is closed in front I shall show there are indications of the primitive mode of formation of the alimentary canal; and in certain peculiarities of the anus, which I shall speak of later, we have indications of the primitive anus of Rusconi; and finally, in the general growth of the epiblast (small cells of the upper pole of the Batrachian egg) over the yolk (lower pole of the Batrachian egg), we have an example of the manner in which the primitive involution, to form the alimentary canal, invariably disappears when the quantity of yolk in an egg becomes very great.

I believe that in the Dog-fish we have before our eyes

[1] This has been already made out by Kowalevsky, "Wurmern u. Arthropoden," loc. cit.

one of the steps by which a direct mode of formation comes to be substituted for an *in*direct one by involution. We find, in fact, in the Dog-fish, that the cells from which are derived the mesoblast and hypoblast come to occupy their final position in the primitive arrangement of the cells during segmentation, and not by a subsequent and secondary involution.

This change in the mode of formation of the alimentary canal is clearly a result of change of mechanical conditions from the presence of the large food-yolk.

Excellent parallels to it will be found amongst the Mollusca. In this class the presence or absence of food-yolk produces not very dissimilar changes to those which are produced amongst vertebrates from the same cause.

The continuity of the hypoblast and epiblast at the embryonic rim is a remnant which, having no meaning or function, except in reference to the earlier mode of development, is likely to become lost, and in Birds no trace of it is any longer to be found.

I will not in the present preliminary paper attempt hypothetically to trace the steps by which the involution gradually disappeared, though I do not think it would be very difficult to do so. Nor will I attempt to discuss the question whether the condition with a large amount of food-yolk (as seems more probable) was twice acquired—once by the Elasmobranchii and Osseous fishes, and once by Reptiles and Birds—or whether only once, the Reptiles and Birds being lineal descendants of the Dog-fish.

In reference to the former point, however, I may mention that the Batrachians are to a certain extent intermediate in condition between the *Amphioxus* and the Dog-fishes, since in them the yolk becomes divided during segmentation into lower layer cells and epiblast, but a modified involution is still retained, while the Dog-fish may be looked upon as intermediate between Birds and Batrachians, the continuity at the hind end between the epiblast and hypoblast being retained by them, though not the involution.

It may be convenient here to call attention to some of the similarities and some of the differences which I have not yet spoken of between the development of Osseous fish and the Dog-fish in the early stages. The points of similarity are—(1) The swollen edge of the blastoderm. (2) The embryo-swelling. (3) The embryo-keel. (4) The spreading of the blastodern over the yolk-sac from a point corresponding with the position of the embryo, and not with the centre of the germ. The growth is almost nothing at that point, and

most rapid at the opposite pole of the blastoderm, being less and less rapid along points of the circumference in proportion to their proximity to the embryonic swelling. (5) The medullary groove.

In external appearance the early embryos of Dog-fish and Teleostei are very similar; some of my drawings could almost be substituted for those given by Oellacher. This similarity is especially marked at the first appearance of the medullary groove. In the Dog-fish the medullary groove becomes converted into the medullary canal in the same way as with Birds and all other vertebrates, except Osseous fishes, where it comes to nothing, and is, in fact, a rudimentary organ. But in spite of Oellacher's assertions to the contrary, I am convinced from the similarity of its position and appearance to the true medullary groove in the Dog-fish, that the groove which appears in Osseous fishes is the true medullary groove; although Oellacher appears to have conclusively proved that it does not become converted into the medullary canal. The chief difference between the Dog-fish and Osseous fish, in addition to the point of difference about the medullary groove, is that the epiblast is in the Dog-fish a single layer, not divided into nervous and epidermic layers as in Osseous fish, and this difference is the more important, since, throughout the whole period of development till after the commencement of the formation of the neural canal, the epiblast remains as a one-cell-deep layer of cells, and thus the possibility is excluded of any concealed division into a neural and epidermic layer, as has been supposed to be the case by Stricker and others in Birds.

Development of the Embryo.

After the embryo has become definitely established, for some time it grows rapidly in length, without externally undergoing other important changes, with the exception of the appearance of two swellings, one on each side of its tail.

These swellings, which I will call the *Caudal lobes* (figs. 8 and 9, *t s*), are also found in Osseous fishes, and have been called by Oellacher the *Embryonal saum.* They are caused by a thickening of mesoblast on each side of the hind end of the embryo, at the edge of the embryonic rim, and form a very conspicuous feature throughout the early stages of the development of the Dog-fish, and are still more marked in the Torpedo (Pl. XIV, fig. 9). Although from the surface the other changes which are visible are very insignificant, sections show that the *notochord* is commencing to be formed.

I pointed out that beneath the medullary groove the epiblast and hypoblast were not separated by any interposed mesoblast. Along the line (where the mesoblast is deficient) which forms the long axis of the embryo, a rod-like thickening of the hypoblast appears (Pl. XIV, figs. 7 *a* and 7 *b*, *ch* and *ch'*), first at the head end of the embryo, and gradually extending backwards. This is the rudiment of the notochord; it remains attached for some time to the hypoblast, and becomes separated from it first at the head end of the embryo, and the separation is then carried backwards. This thickening of the hypoblast projects up and comes in contact with the epiblast, and in the later stages with bad (especially chromic-acid) specimens the line of separation between the epiblast and the thickening may become a little obscured, and might possibly lead to the supposition that a structure similar to that which has been called the "*axis cord*" was present. In all my best (osmic-acid) specimens the line of junction is quite clear; and any one who is aware how easily two separate masses of cells may be made indistinguishably to fuse together from simple pressure will not be surprised to find the occasional obscurity of the line of junction between the epiblast and hypoblast. In the earlier stage of the thickening there is never in the osmic-acid preparations any appearance of fusion except in very badly prepared ones. Its mode of formation will be quite clear without further description from an inspection of Pl. XIV, figs. 7 *a* and 7 *b*, *ch* and *ch'*. Both are taken from one embryo. In fig. 7 *b*, the most anterior of the two, the notochord has become quite separated from the hypoblast. In fig. 7 *a*, *ch*, there is only a very marked thickening of hypoblast, which reaches up to the epiblast, but the thickening is still attached to the hypoblast. Had I had space to insert a drawing of a third section of the same embryo there would only have been a slight thickening of the hypoblast. In the earlier stage it will be seen, by referring to figs. 6 *a* and 6 *b*, that there is no sign of a thickening of the hypoblast. My numerous sections (all made from embryos hardened in osmic acid) showing these points are so clear that I do not think there can be any doubt whatever of the notochord being formed as a thickening of the hypoblast. Two interpretations of this seem possible.

I mentioned that the mesoblast appeared to be primitively formed as two independent sheets, *split off, so to speak, from the hypoblast*, one on each side of the middle line of the embryo. If we looked upon the notochord as a third *median sheet of mesoblast*, split off from the hypoblast somewhat later

than the other two, we should avoid having to admit its hypoblastic origin.

Professor Huxley, to whom I have shown my specimens, strongly advocates this view.

The other possibility is that the notochord is primitively a true *hypoblastic* structure which has only by adaptation become an apparently *mesoblastic* one in the higher vertebrates. In favour of this view are the following considerations:

(1) That this is the undoubtedly natural interpretation of the sections. (2) That the notochord becomes separated from the hypoblast after the latter has acquired its typical structure, and differs in that respect from the two lateral sheets of mesoblast, which are formed coincidently with the hypoblast by a homogeneous mass of cells becoming differentiated into two distinct layers. (3) That the first mode of looking at the matter really proves too much, since it is clear that by the same method of reasoning we could prove the mesoblastic origin of any organ derived from the hypoblast and budded off into the mesoblast. We should merely have to assert that it was really a mass of mesoblast budded off from the hypoblast rather later than the remainder of the mesoblast. Still, it must be admitted that the first view I have suggested is a possible, not to say a probable one, though the mode of arguing by which it can be upheld may be rather dangerous if generally applied. We ought not, however, for that reason necessarily reject it in the present case. As Mr. Ray Lankester pointed out to me, if we accept the hypoblastic origin of the notochord, we should find a partial parallel to it in the endostyle of Tunicates, and it is perhaps interesting to note in reference to it that the notochord is the only *unsegmented* portion of the axial skeleton.

Whether the strong *à priori* arguments against the hypoblastic origin of the notochord are sufficient to counterbalance the natural interpretations of my sections, cannot, I think, be decided from the single case of the Dog-fish. It is to be hoped that more complete investigations of the Lamprey, &c., may throw further light upon the question.

Whichever view of the primitive origin of the notochord is the true one, its apparent origin is very instructive as illustrating the possible way in which an organ might come to change the layer to which it primarily belonged.

If the notochord is originally a mesoblastic structure, it is easy to be seen how, by becoming separated from the hypoblast a little later than is the case with the Dog-fish, its true mesoblastic origin would become lost; while if, on the other

hand, it is primitively a hypoblastic structure, we see from higher vetebrates how, by becoming separated from the hypoblast rather earlier than in the Dog-fish, viz. at the same time as the rest of the mesoblast, its primitive derivation from the hypoblast has become concealed.

The view seemingly held by many embryologists of the present day, that an organ, when it was primitively derived from one layer, can never be apparently formed in another layer, appears to me both unreasonable on *à priori* grounds and also unsupported by facts.

I see no reason for doubting that the embryo in the earliest periods of development is as subject to the laws of natural selection as is the animal at any other period. Indeed, there appear to me grounds for the thinking that it is more so. The remarkable differences in allied species as to the amount of food-yolk, which always entail corresponding alterations in the development—the different modes of segmentation in allied species, such as are found in the Amphipoda and Isopoda—the suppression of many stages in freshwater species, which are retained in the allied marine species—are all instances of modifications due to natural selection affecting the earliest stages of development. If such points as these can be affected by natural selection I see no reason why the arrangement of individual cells (or rather primitive elements) should not also be modified; why, in fact, a mass of cells which was originally derived from one layer, but in the course of development became budded off from that layer and entered another layer, should not by a series of small steps cease ever to be attached to the original layer, but from the first moment it can be distinguished should be found as a separate mass in the second layer.

The change of layers will, of course, only take place where some economy is effected by it. The variations in the mode of development of the nervous system may probably be explained in this way.

If we admit that organs can undergo changes, as to the primitive layer from which they are derived, important consequences must follow.

It will, for instance, by no means be sufficient evidence of two organs not being homologous that they are not developed from the same layer. It renders the task of tracing out the homologies from development much more difficult than if the ordinary view of the invariable correspondence of the three layers throughout the animal kingdom be accepted. Although I do not believe that this correspondence is invari-

able or exact, I think that we both find and should expect to find that it is, roughly speaking, fairly so.

Thus, the muscles, internal skeleton, and connective tissue are always placed in the adult between the skin (epidermis) and the epithelium of the alimentary canal.

We should therefore expect to find them, and, as a matter of fact, we always do find them, developed from a middle layer when this is present.

The upper layer must always and does always form the epidermis, and similarly the lower layer or hypoblast must form a part of the epithelium of the alimentary canal. A full discussion of this question would, however, lead me too far away from my present subject.

The only other point of interest which I can touch on in this stage is the commencing closure of the alimentary canal in the region of the head. This is shown in Pl. XIII, fig. 6 *a*, 6 *b*, and Pl. XIV, 7 *b*, *n. a.* From these figures it can be seen that the closing does not take place as much by an infolding as by an ingrowth from the side walls of the alimentary canal towards the middle line. In this abnormal mode of closing of the alimentary canal we have again, I believe, an intermediate stage between the mode of formation of the alimentary canal in the Frog and the typical folding in which occurs in Birds. There is, however, another point in reference to it which is still more interesting. The cells to form the ingrowth from the bottom (ventral) wall of the alimentary canal are derived by a continuous fresh formation from the yolk, being formed around the nuclei spoken of above (*vide* p. 329). All my sections show this with more or less clearness, especially those a little later than fig. 6 *b*, in which the lower wall of the alimentary canal is nearly completed. This is the more interesting since, from the mode of formation of the alimentary canal in the Batrachians, &c., we might expect that the cells from the yolk would take a share in its formation in the Dog-fish. I have not as yet made out for certain the share which is taken by these freshly formed cells of the yolk in the formation of any other organ.

By the completion of its lower wall in the way described, the throat early becomes a closed tube, its closing taking place before any other important changes are visible in the embryo from surface views.

A considerable increase in length is attained before other changes than an increase in depth of the medullary groove and a more complete folding off of the embryo from the blastoderm take place. The first important change is the formation of the protovertebræ.

These are formed by the lateral plates of mesoblast, which I said were equivalent at once to the vertebral and lateral plates in the Bird, becoming split by transverse divisions into cubical masses.

At the time when this occurs, and, indeed, up till a considerably later period, the mesoblast is not split into somatopleure and splanchnopleure, and it is not divided into vertebral and lateral plates. The transverse lines of division of the protovertebræ do not, however, extend to the outer edge of the undivided lateral plates.

The differences between this mode of formation of the protovertebræ and that occurring in Birds are too obvious to require pointing out. I will speak of them more fully when I have given the whole history of the protovertebræ of the Dog-fish.

I will only now say that I have had in the early stages to investigate the formation of the protovertebræ entirely by means of sections, the objects being too opaque to be otherwise studied.

The next change of any importance is the commencement of the formation of the head. The region of the head first becomes distinguishable by the flattening out of the germ at its front end.

The flattened-out portion of the germ grows rapidly, and forms a spatula-like termination to the embryo (Pl. XIII, fig. 8).

In the region of the head the medullary groove is at first totally absent (*vide* section, Pl. XIV, fig. 8 *a*).

Indeed, as can be seen from fig. 8 *b*, the laminæ dorsales, so far from bending up at this stage, actually bend down in the opposite direction.

I am at present quite unable even to form a guess what this peculiar feature of the brain means. It, no doubt, has some meaning in reference to the vertebrate ancestry if we could only discover it. The peculiar spatula-like flattened condition of the head is also (*vide* loc. ant. cit.) apparently found in the Sturgeons; it must therefore almost undoubtedly be looked upon as not merely an accidental peculiarity.

While these changes have been taking place in the head not less important changes have occurred in the remainder of the body. In the first place the two caudal lobes have increased in size, and have become, as it were, pushed in together, leaving a groove between them (fig. 8, *t s*). They are very conspicuous objects, and, together with the spatula-like head, give the whole embryo an almost comical appear-

ance. The medullary canal has by this time become completely closed in the region of the tail (figs. 8 and 8 *b*).

It is still widely open in the region of the back, and, though more nearly closed again in the neck, is, as I have said, flattened out to nothing in the head.

The groove[1] between the two caudal lobes must not be confused (as may easily be done) with the medullary groove, which by the time the former groove has become conspicuous is a completely closed canal.

The vertebral plates are not divided (*vide* fig. 7) into a somatopleuric and splanchnopleuric layer by this stage, except in the region of the head (*vide* fig. 8 *a*, *p p′*), where there is a distinct space between the two layers, which is undoubtedly homologous with the pleuro-peritoneal cavity of the hinder portion of the body.

It is probably the same cavity which Oellacher (loc. cit.) calls in Osseous fishes the pericardial cavity. In the Dog-fish, at least, it has no connection with the pericardium. Of its subsequent history I shall say a few words when I come to speak of the later stages.

The embryo does not take more than twenty-four hours in passing from this stage, when the head is a flat plate, to the stage when the whole neural canal (including the region of the head) is closed in. The other changes, in addition to the closing in of the neural canal, are therefore somewhat insignificant. The folding off of the embryo from the germ has, however, progressed considerably, and a portion of the hind gut is closed in below. This is accomplished, not by a tail-fold, as in Birds, but by two lateral folds, which cause the sides of the body to meet and coalesce below. At the extreme hind end, where the epiblast is continuous with the hypoblast, the lateral folds turn round, so to speak, and become continuous with the medullary folds, so that when the various folds meet each other an uninterrupted canal is found passing round from the neural into the alimentary canal, and placing these two in communication at the tail end of the body. Since I have already mentioned this, and spoken of its significance, I will not dwell on it further here.

The cranial flexure commences coincidently with the closing in of the neural canal in region of the brain, and the division into fore, mid, and hind brain becomes visible at the same time as or even before the closing of the canal occurs. The embryo has now become more or less transparent, and proto-

[1] This groove is the only structure which it seems possible to compare with the so-called "primitive groove" of Birds. It is, however, doubtful whether they are really homologous.

vertebræ, of which about twenty are present, can *now* be seen in the fresh specimens. The heart, however, is not yet formed.

Up to this period, a period at which the embryo becomes very similar in external appearance to any other vertebrate embryo, I have followed in my description a chronological order. I shall now cease to do so, since it would be too long for a preliminary notice of this kind, but shall confine myself to the history of a few organs whose development is either more important or more peculiar than that of the others.

The Protovertebræ.

I have thought it worth while to give a short history of the development of the protovertebræ, firstly, because it is very easy to follow this in the Dog-fish, and, secondly, because I believe that the Dog-fish have more nearly retained the primitive condition of the protovertebræ than any other vertebrate whose embryology has hitherto been described with sufficient detail.

I intend to describe, at the same time, the development of the spinal nerves.

I left each lateral mass of mesoblast in my last stage as a plate which had not yet become split into a somatic and a splanchnic sheet (Pl. XIV, fig. 8 *a, v p*), but which had become cut by transverse lines (not, indeed, extending to the outer limit of the sheet, but as yet not cut off by longitudinal lines of cleavage) into segments, which I called protovertebræ.

This sheet of mesoblast is fairly thick at its proximal (upper) end, but thins off laterally to a sheet two cells deep, and its cells are so arranged as to foreshadow its subsequent splitting into somatic and splanchnic sheets. Its upper (proximal) end is at this stage level with the bottom of the neural canal, but soon begins to grow upwards, and at the same time the splitting into somatopleure and splanchnopleure commences (Pl. XIV, fig. 10, *s o* and *s p*).

The separation between the two sheets is first visible in its uppermost part, and thence extends outwards. By this means each of the protovertebræ becomes divided into two sheets, which are only connected at their upper ends and outside the region of the body. I speak of the whole lateral sheet as being composed of protovertebræ, because at this time no separation into vertebral and lateral plates can be seen; but I may anticipate matters by saying that only the upper portion of the sheet from the level of the top of the digestive canal, becomes subsequently the true protovertebræ; so that it is clear that

the pleuro-peritoneal cavity extends primitively quite up to the top of the protovertebræ; and that thus a portion of a sheet of mesoblast, at first perfectly continuous with the splanchnic sheet from which is derived the muscular wall of the alimentary canal, is converted into a part of the voluntary muscular system of the body, having no connection whatever with the involuntary muscular system of the digestive tract.

The pleuro-peritoneal cavity is first distinctly formed at a time when only two visceral clefts are present. Before the appearance of a third visceral cleft in a part of the innermost layer of each protovertebræ (which may be called the splanchnic layer, from its being continuous with the mesoblast of the splanchnopleure), opposite the bottom of the neural tube, some of the cells commence to become distinguishable from the rest, and to form a separate mass. This mass becomes much more distinct a little later, its cells being characterised by being spindle-shaped, and having an elongated nucleus which becomes deeply stained by reagents (Pl. XV, fig. 11, *m p'*). Coincidently with its appearance the young Dog-fish commences spontaneously to move rapidly from side to side with a kind of serpentine motion, so that, even if I had not traced the development of this differentiated mass of cells till it becomes a band of muscles close to the notochord, I should have had little doubt of its muscular nature. It is indicated in figs. 11, 12, 13, by the letters *m p'*. Its early appearance is most probably to be looked upon as an adaptation consequent upon the respiratory requirements of the young Dog-fish necessitating movements within the egg.

Shortly after this date, at a period when three visceral clefts are present, I have detected the first traces of the spinal nerves.

At this time they appear in sections as small elliptical masses of cells, entirely independent of the protovertebræ, and closely applied to the upper and outer corners of the involuted epiblast of the neural canal (Pl. XV, fig. 11, *sp n*). These bodies are far removed from any mesoblastic structures, and at the same time the cells composing them are *not* similar to the cells composing the walls of the neural canal, and are not attached to these, though lying in contact with them. I have not, therefore, sufficient evidence at present to enable me to say with any certainty where the spinal nerves are derived from in the Dog-fish. They may be derived from the involuted epiblast of the neural canal, and, indeed, this is the most natural interpretation of their position.

On the other hand, it is possible that they are formed from wandering cells of the mesoblast—a possibility which, with

our present knowledge of wandering cells, must not be thrown aside as altogether improbable.

In any case, it is clear that the condition in the Bird, where the spinal nerves are derived from tissue of the protovertebræ, is not the primitive one. Of this, however, I will speak again when I have concluded my account of the development of the protovertebræ.

About the same time that I have found the rudiments of the nerves the division of the mesoblast of the sides of the body into a vertebral and a lateral portion occurs. This division first appears in the region where the oviduct (Müller's duct) is formed (Pl. XV, fig. 11, *ov*).

At this part opposite the level of the dorsal aorta the two sheets, viz. the splanchnic and the somatic, unite together, and thus each lateral sheet of mesoblast becomes divided into an upper portion (fig. 11, *m p*), split up by transverse partitions into protovertebræ, and a lower portion not so split, but consisting of an outer layer, the true somatopleure, and an inner layer, the true splanchnopleure. These two divisions of the primitive plate are thus separated by the line at which a fusion between the mesoblast of the somatopleure and splanchnopleure takes place. The mass of cells resulting from the fusion at this point corresponds with the intermediate cell-mass of Birds (*vide* Waldeyer, 'Eierstock und Ei').

At the same time, in the upper of these two sheets, the splanchnic layer sends a growth of cells inwards towards the notochord and the neural canal. This growth is the commencement of the large quantity of mesoblastic tissue around the notochord, which is in part converted into the axial skeleton, and in part into the connective tissue adjoining this.

This mass of cells is at first quite continuous with the splanchnic layer of the protovertebræ, and I see no reason for supposing that it is not derived from the growth of the cells of this layer. The ingrowth to form it first appears a little after the formation of the dorsal aorta; but, as far as I have been able to see, its cells have no connection with the walls of the aorta.

What I have said as to the development of the skeleton-forming layer will be quite clear from figs. 11 and 12 *a*; and from these it will also be clear, especially from fig. 11 *a*, that the outermost layer of this mass of cells, which was the primitive splanchnic layer of the protovertebræ, still retains its epithelial character, and so can easily be distinguished from those cells which will form the skeleton. In the next stage which I have figured (fig. 12 *a*), this outer portion of the

splanchnic layer is completely separated from the skeleton-forming cells, and at the same time having united below as well as above with the outer (somatic) layer of the two layers of which the protovertebræ are formed, the two together form an independent mass (fig. 12, *m p*), similar in appearance and in every way homologous with the muscle-plate of Birds.

On the inner side of this, which we may now call the muscle-plate, is seen the bundle of earlier-developed muscles (fig. 12, *mp'*) which I spoke of before.

The section represented in fig. 12 is from a very considerably later embryo than that represented in fig. 11, so that the skeleton-forming cells, few in number in the earlier section, have become very numerous in the later one, and have grown up above the neural canal, and also below the notochord, between the digestive canal and the aorta. They have, moreover, changed their character; they were round before, now they have become stellate. As to their further history, I will only say that the layer of them immediately around the notochord and neural canal forms the cartilaginous centra and arches of the vertebræ, and that the remaining portion of them, which becomes much more insignificant in size as compared with the muscles, forms the connective tissue of the skeleton and of the parts around and between the muscles.

A muscle-plate itself is at this stage (shown in fig. 12) composed of an inner and an outer layer of epithelium (splanchnic and somatic) united at the upper and lower ends of the plate, and on the inner of the two lies the more developed mass of muscles before spoken of (*m p'*).

Each of these plates now grows both upwards and downwards; and at the same time connective-tissue cells appear between the plates and epidermis; but from where they come I do not know for certain; very probably they are derived from the somatic layer of the muscle-plate.

While the muscle-plates continue to grow both upwards and downwards, the cells of which they are composed commence to become elongated and soon acquire an unmistakably muscular character (Pl. XV, fig. 13, *m p*).

Before this has occurred the inner mass of muscles has also undergone further development and become a large and conspicuous band of muscles close to the notochord (fig. 13, *m p'*).

At the same time that the muscle-plates acquire the true histological character of muscle, septa of connective tissue grow in and divide them into a number of distinct seg-

ments, which subsequently form separate bands of muscle. I will not say more in reference to the development of the muscular system than that the whole of the muscles of the body (apart from the limbs, the origin of whose muscular system I have not yet investigated) are derived from the muscle-plates which grow upwards above the neural canal and downwards to the ventral surface of the body.

During the time the muscle-plates have been undergoing these changes the nerve masses have also undergone developmental changes.

They become more elongated and fibrous, their main attachment to the neural tube being still at its posterior (dorsal) surface, near which they first appeared. Later they become applied closely to the sides of the neural tube and send fibres to it below as well as above. Below (ventral to) the neural tube a ganglion appears, forming only a slight swelling, but containing a number of characteristic nerve-cells. The ganglion is apparently formed just below the junction of the anterior and posterior roots, though probably the fibres of the two roots do not mix till below it.

The main points which deserve notice in the development of the protovertebræ are—

(1) That at the time when the mesoblast becomes split herizontally into somatopleure and splanchnopleure the vertebral and lateral plates are one, and the splitting extends to the very top of the vertebral plate, so that the future muscle-plates are divided into a splanchnic and somatic layer, the space between which is at first continuous with the pleuro-peritoneal cavity.

(2) That the following parts are respectively formed by the vertebral and lateral plates:

(*a*) Vertebral plate. From the splanchnic layer of this, or from cells which appear close to and continuous with it, the skeleton, and connective tissue of the upper part of the body, are derived.

The remainder of the plate, consisting of a splanchnic and somatic layer, is entirely converted into the muscles of the trunk, all of which are derived from it.

(*b*) Between the vertebral plate and the lateral plate is a mass of cells where, as I mentioned above, the mesoblast of the somatopleure and splanchnopleure fuse together. This mass of cells is the equivalent of the *intermediate cell* mass of Birds (*vide* Waldeyer, 'Eierstock und Ei').

From it are derived the Wolffian bodies and duct, the oviduct, the ovaries and the testis, and the connective tissue of the parts adjoining these.

(*c*) The lateral plate. From the somatic layer of this is derived the connective tissue of the ventral half of the body; the mesoblast of the limbs, including probably the muscles, and certainly the skeleton. From its splanchnic layer are derived the muscles and connective tissue of the alimentary canal.

(3) The spinal nerves are developed independently of the protovertebræ, so that the protovertebræ of the Elasmobranchii do not appear to be of such a complicated structure as the protovertebræ of Birds.

The Digestive Canal.

I do not intend to enter into the whole history of the digestive canal, but to confine myself to one or two points of interest connected with it. These fall under two heads:

(1) The history of the portion of the digestive canal between the anus and the end of the tail where the digestive canal opens into the neural canal.

(2) Certain less well-known organs derived from the digestive canal.

The anus is a rather late formation, but its position becomes very early marked out by the hypoblast of the digestive canal approaching at that point close to the surface, whilst receding to some little distance from it on either side. The portion of the digestive tract I propose at present dealing with is that between this point, which I will call, for the sake of brevity, the anus, and the hind end of the body. This portion of the canal is at first very short; it is elliptical in section, and of rather a larger bore than the remainder of the canal. Its diameter becomes, however, slightly less as it approaches the tail, dilating again somewhat at its extreme end. It is lined by a markedly columnar epithelium. Though at first very short, its length increases with the growth of the tail, but at the same time its calibre continually becomes smaller as compared with the remainder of the alimentary canal.

It commences to become smaller, first of all, near, though not quite, at its extreme hind end, and thus becomes of a conical shape; the base of the cone being just behind the anus, while the apex of the cone is situated a short distance from the hind end of the embryo. The extreme hind end, however, at the same time does not diminish in size, and becomes relatively (if not also absolutely) much larger in diameter than it was at first, as compared with the remainder of the digestive canal. It becomes, in fact, a vesicle or vesicular dilatation at the end of a conical canal.

Just before the appearance of the external gills this part of the digestive canal commences to atrophy. It begins to do so close to the terminal vesicle, which, however, still remains as or more conspicuous than it was before. The lumen of the canal becomes smaller and smaller, and finally it becomes a solid string of cells, and these also soon disappear and not a trace of the canal is left.

Almost the whole of it has disappeared before the vesicle begins to atrophy, but very shortly after all trace of the rest of the canal has vanished the terminal vesicle also vanishes. This occurs just about the time or shortly after the appearance of the external gills—there being slight differences probably in this respect in the different species.

In this history there are two points of especial interest:

(1) The terminal vesicle.

(2) The disappearance of a large and well-developed portion of the alimentary canal.

The interest in the terminal vesicle lies in the possibility of its being some rudimentary structure.

In Osseous fishes Kuppfer has described the very early appearance of a vesicle near the tail end, which he doubtfully speaks of as the "allantois." The figure he gives of it in his earlier paper ('Archiv. für Micro. Anat.' vol. ii, pl. xxiv, fig. 2) bears a very strong resemblance to my figures of this vesicle at the time when the hind end of the alimentary canal is commencing to disappear; and I feel fairly confident that it is the same structure as I have found in the Dog-fish: but until the relations of the Kuppfer's vesicle to the alimentary canal are known, any comparison between it and the terminal vesicle in the Dog-fish must be to a certain extent guess-work.

I have, however, been quite unsuccessful in finding any other vesicular structure which can possibly correspond to the so-called allantoic vesicle of Osseous fish.

The disappearance of a large portion of the alimentary canal behind the anus is very peculiar. In order, however, to understand the whole difficulties of the case I shall be obliged to speak of the relations of the anus of the Dog-fish to the anus of Rusconi in the Lamprey, &c.

In those vertebrates whose alimentary canal is formed by an involution, the anus of Rusconi represents the opening of this involution, and therefore the point where the alimentary canal primitively communicates with the exterior. When, however, the "anus of Rusconi" becomes *closed*, the wall of the alimentary canal still remains at that point in close juxtaposition to the surface, and the new and final anus is

formed at or close to that point. In the Dog-fish, although the anus of Rusconi is not present, still, during the closing of the alimentary canal, the point which would correspond with this becomes marked out by the alimentary canal there approaching the surface, and it is at this point that the involution to form the true anus subsequently appears.

The anus in the Dog-fish has thus, more than a mere secondary significance. It corresponds with the point of closing of the primitive involution. If it was not for this peculiarity of the vertebrate anus we would naturally suppose, from the disappearance of a considerable portion of the alimentary canal lying behind its present termination, that in the adult the alimentary canal once extended much farther back than at present, and that the anus we now find was only a secondary anus, and not the primitive one. It is perhaps possible that this hinder portion of the alimentary canal is a result of the combined growth of the tail and the persisting continuity (at the end of the body) of the epiblast with the hypoblast.

Whichever view is correct, it may be well to mention, in order to show that the difficulty about the anus of Rusconi is no mere visionary one, that Götte ("Untersuchung über die Entwickelung der Bombinator igneus," 'Archiv. für Micro. Anat.,' vol. v, 1869) has also described the disappearance of the hind portion of the alimentary canal in Batrachians, a rudiment (according to him) remaining in the shape of a lymphatic trunk.

It is, perhaps, possible that we have a further remnant of this "hind portion" of the alimentary canal amongst the higher vertebrates in the "allantois."

Organs developed from the Digestive Canal.

In reference to the development of the liver, pancreas, &c., as far as my observations have at present gone, the Dog-fish presents no features of peculiar interest. The liver is developed as in the Bird, and independently of the yolk.

There are, however, two organs derived from the hypoblast which deserve more attention. Immediately under the notochord, and in contact with it (*vide* Pl. XIV, fig. 10; XV, 11 and 12, *x*), a small roundish (in section) mass of cells is to be seen in most of the sections.

Its mode of development is shown in fig. 10, *x*. That section shows a mass of cells becoming pinched off from the top of the alimentary canal. By this process of pinching off from the alimentary canal a small rod-like body close under the notochord is formed. It persists till after the appearance

of the external gills, but later than that I have not hitherto succeeded in finding any trace of it.

It was first seen by Götte (loc. cit.) in the Batrachians, and he gave a correct account of its development, and added that it became the thoracic duct.

I have not myself worked out the later stages in the development of this body with sufficient care to be in a position to judge of the correctness of Götte's statements as to its final fate. If it is true that it becomes the thoracic duct it is very remarkable, and ought to throw some light upon the homologies of the lymphatic system.

Some time before the appearance of the external gills another mass of cells becomes, I believe, constricted off from the part of the alimentary canal in the neighbourhood of the anus, and forms a solid rod composed at first of dark granular cells lying between the Wolffian ducts. I have not followed out its development quite completely, but I have very little doubt that it is really constricted off from a portion of the alimentary canal chiefly in front of the point where the anus appears, but also, I believe, from a small portion behind this.

Though the cells of which it is composed are at first columnar and granular (fig. 12, *s u, r*), they soon begin to become altered, and in the latter stage of its development the body forms a conspicuous rounded mass of cells with clear protoplasm, and each provided with a large nucleus. Later still it becomes divided into a number of separate areas of cells by septa of connective tissue, in which (the septa) capillaries are also present. Since I have not followed it to its condition in the adult, I cannot make any definite statements as to the fate of this body; but I think that it possibly becomes the so-called supra-renal organ, which in the Dog-fish forms a yellowish elongated body lying between the two kidneys.

The development of the Wolffian Duct and Body and of the Oviduct.

The development of the Wolffian duct and the Oviduct in the various classes of vertebrates is at present involved in some obscurity, owing to the very different accounts given by different observers.

The manner of development of these parts in the Dog-fish is different from anything that previous investigators have met with in other classes, but I believe that it gives a clearer insight into the true constitution of these parts than vertebrate embryology has hitherto supplied, and at the same

time renders easier the task of understanding the differences in the modes of development in the different classes.

I shall commence with a simple description of the observed facts, and then give my view as to their meaning. At about the time of the appearance of the third visceral cleft, and a short way behind the point up to which the alimentary canal is closed in front, the splanchnopleure and somatopleure fuse together opposite the level of the dorsal aorta.

From the mass of cells formed by this fusion a solid knob rises up towards the epiblast (Pl. XV, fig. 11 *b*, *o v*), and from this knob a solid rod of cells grows backwards towards the tail (fig. 11 *c*, *o v*) very closely applied to the epiblast. This description will be rendered clear by referring to figs. 11 *b* and *c*. Fig. 11 *b* is a section at the level of the knob, and fig. 11 *c* is a section of the same embryo a short way behind this point. So closely does the rod of cells apply itself to the epiblast that it might very easily be supposed to be derived from it. Such, indeed, was at first my view till I cut a section passing through the knob. In order, however, to avoid all possibility of mistake I made sections of a large number of embryos of about the age at which this appears, and *invariably found* the large knob in front, and from it the solid string growing backwards.

This string is the commencement of the *Oviduct* or *Müller's duct*, which in the Dog-fish as in the Batrachians is the first portion of the genito-urinary system to appear, and is in the Dog-fish undoubtedly at first solid. All my specimens have been hardened with osmic acid, and with specimens hardened with this reagent it is quite easy to detect even the very smallest hole in a mass of cells.

As a solid string or rod of cells the Oviduct remains for some time; it grows, indeed, rapidly in length, the extreme hind length of the rod being very small and the front end continuing to remain attached to the knob. The knob, however, travels inwards and approaches nearer and nearer to the true pleuro-peritoneal cavity, always remaining attached to the intermediate cell mass.

At about the time when five visceral clefts are present the Oviduct first begins to get a lumen and to open at its front end into the pleuro-peritoneal cavity. The cells of the rod are first of all arranged in an irregular manner, but gradually become columnar and acquire a radiating arrangement around a central point. At this point, where the ends of all the cells meet, a very small hole appears, which gradually grows larger and becomes the cavity of the duct (fig. 12, *o v*). The hole first makes its appearance at the anterior end of the

duct, and then gradually extends backwards, so that the hind end is still without a lumen, when the lumen of the front end is of a considerable size.

At the front knob the same alteration in the cells takes place as in the rest of the duct, but the cells become deficient on the side adjoining the pleuro-peritoneal cavity, so that an opening is formed into the pleuro-peritoneal cavity, which soon becomes of a considerable size. Soon after its first formation, indeed, the opening becomes so large that it may be met in from two to three consecutive sections if these are very thin.

Thus is formed the lumen of the Oviduct. The duct still, at this age, ends behind without having become attached to the cloaca, so that at this time the Oviduct is a canal closed behind, but communicating in front by a large opening with the pleuro-peritoneal cavity.

It has during this time been travelling downwards, and is now much nearer the pleuro-peritoneal cavity than the epiblast.

It may be well to point out that the mode of development which I have described is really not very different from an involution, and must, in fact, be only looked upon as a modification of an involution. Many examples from all classes in the animal kingdom could be selected to exemplify how an involution may become simply a solid thickening. In the Osseous fish nearly all the organs which are usually formed by an involution have undergone this change in their mode of development. I shall attempt to give reasons later on for the solid form having been acquired in this particular case of the Oviduct.

At about the time when a lumen appears in the Oviduct the first traces of the Wolffian duct become visible.

At intervals along the whole length, between the front and hind ends of the Oviduct, involutions arise from the pleuro-peritoneal cavity (fig. 12, *a, p, w d*) on the inside (nearer the middle line) of the Oviduct. The upper ends of these numerous involutions unite together and form a string of cells, at first solid, but very soon acquiring a lumen, and becoming a duct which communicates (as it clearly must from its mode of formation), at numerous points with the pleuro-peritoneal cavity. It is very probable that there is one involution to each segment of the body between the front and hind ends of the Oviduct. This duct is the Wolffian duct, which thus, together with the Oviduct, is formed before the appearance of the external gills.

For a considerable period the front end of the Oviduct

does not undergo important changes; the hind end, however, comes into connection with the extreme end of the alimentary canal. The two Oviducts do not open together into the cloaca, though, as my sections prove, their openings are very close together. The whole Oviduct, as might be expected, shares in the general growth, and its lumen becomes in both sexes very considerably greater than it was before.

It is difficult to define the period at which I find these changes accomplished without giving drawings of the whole embryo. The stage is one considerably after the external gills have appeared, but before the period at which the growth of the olfactory bulbs renders the head of an elongated shape.

During the same period the Wolffian duct has undergone most important changes. It has commenced to bud off diverticula, which subsequently become the tubules of the Wolffian body (*vide* fig. 13, *w d*). I am fairly satisfied that the tubules are really budded off, and are not formed independently in the mesoblast. The Dog-fish agrees so far with Birds, where I have also no doubt the tubules of the Wolffian body are formed as diverticula from the Wolffian duct.

The Wolffian ducts have also become much longer than the Oviduct, and are now found behind the anus, though they do not extend as far forward as does the Oviduct.

They have further acquired a communication with the Oviduct, in the form of a narrow duct passing from each of them into an Oviduct a short way before the latter opens into the cloacal dilatation of the alimentary canal.

The canals formed by the primitive involution leading from the pleuro-peritoneal cavity into the Wolffian duct have become much more elongated, and at the same time narrower. One of these is shown in fig. 13, *p, w d*.

Any doubt which could possibly be entertained as to the true character of the ducts whose development I have described is entirely removed by the development of the tubules of the Wolffian body. In the still later stage than this further proofs are furnished involving the function of the Oviduct. At the period when the olfactory lobes have become so developed as to render the head of the typical elongated shape of the adult, I find that the males and females can be distinguished by the presence in the former of the clasping appendages.[1] I find at this stage that in the female the front ends of the Oviducts have approached the

[1] For the specimens of this age I am indebted to Professor Huxley.

middle line, dilated considerably, and commenced to exhibit at their front ends the peculiarities of the adult. In the male they are much less conspicuous, though still present.

At the same time the tubules of the Wolffian body become much more numerous, the Malpighian tufts appear, and the ducts cease almost, if not entirely, to communicate with the pleuro-peritoneal cavity. I have not made out anything very definitely as to the development of the Malpighian tufts, but I am inclined to believe that they arise independently in the mesoblast of the intermediate cell mass.

The facts which I have made out in reference to the development of the Wolffian duct, especially of its arising as a *series of involutions* from the pleuro-peritoneal cavity, will be found, I believe, of the greatest importance in understanding the true constitution of the Wolffian body. To this I will return directly, but I first wish to clear the ground by insisting upon one preliminary point.

From their development the Oviduct and Wolffian body appear to stand to each other in the relation of the Wolffian duct being the equivalent to a series, so to speak, of Oviducts.

I pointed out before that the mode of development of the Oviduct could only be considered as a modification of a simple involution from the pleuro-peritoneal cavity. Its development, both in the Birds and in the Batrachians as an involution, still more conclusively proves the truth of this view.

The explanation of its first appearing as a solid rod of cells which keeps close to the epiblast is, I am inclined to think, the following. Since the Oviduct had to grow a long way backwards from its primitive point of involution, it was clearly advantageous for it not to bore its way through the mesoblast of the intermediate cell mass, but to pass between this and the epiblast. This modification having been adopted, was followed by the knob forming the origin of the duct coming to be placed at the outside of the intermediate cell mass rather than close to the pleuro-peritoneal cavity, a change which necessitated the mode of development by an involution being dropped and the solid mode of development substituted for it, a lumen being only subsequently acquired.

In support of the modification in the development being due to this cause is the fact that in Birds the modes of development of the Wolffian duct and the Oviduct are inverted. The Wolffian duct there arises differently from its mode of development in all the lower vertebrates as a solid rod close to the epiblast.[1]

If the above explanation about the Oviduct be correct,

[1] If Romiti's observations ('Archives für Mikr. Anatom.,' vol. ix, p.

then it is clear that similar causes have produced a similar modification in development (only with a different organ) in Birds; while, at the same time, the primitive mode of origin of the Oviduct (Müller's duct) has been retained by them.

The Oviduct, then, may be considered as arising by an involution from the pleuro-peritoneal cavity.

The Wolffian duct arises by a series of such involutions, all of which are behind (nearer the tail) the involution to form the Oviduct.

The natural interpretation of these facts is that in the place of the Oviduct and Wolffian body there were primitively a series of similar bodies (probably corresponding in number with the vertebral segments), each arising by an involution from the pleuro-peritoneal cavity; and that the first of these subsequently became modified to carry eggs, while the rest coalesced to form the Wolffian duct.

If we admit that the Wolffian duct is formed by the coalescence of a series of similar organs, we shall only have to extend the suggestion of Gegenbaur as to the homology of the Wolffian body in order to see its true nature. Gegenbaur looks upon the whole urino-genital system as homologous with a pair of segmental organs. Accepting its homology with the segmental organs, its development in Elasmobranchii proves that it is not one pair, but a series of pairs of segmental organs with which the urino-genital system is homologous. The first of these have become modified so as to form the Oviducts, and the remainder have coalesced to form the Wolffian ducts.

The part of a segmental organ which opens to the exterior appears to be lost in the case of all but the last one, where this part is still retained, and serves as the external opening for all.

Whether the external opening of the first segmental organ (Oviduct) is retained or not is doubtful. Supposing it has been lost, we must look upon the external opening for the Wolffian body as serving also for the Oviduct. In the case of all other vertebrates whose development has been investigated (but the Elasmobranchii), the Wolffian duct arises by a single involution, or, what is equivalent to it, the other involutions having disappeared. This even appears to be the case in the Marsipobranchii. In the adult Lamprey the Wolffian duct terminates at its anterior end by a large

200) are correct, then the ordinary view of the Wolffian duct arising in Birds as a solid rod at the outer corner of the protovertebræ will have to be abandoned.

ciliated opening into the pleuro-peritoneal cavity. It will, perhaps, be found, when the development of the Marsipobranchii is more carefully studied, that there are *primitively* a number of such openings.[1] The Oviduct, when present, arises in other vertebrates as a single involution, strongly supporting the view that its mode of formation in the Dog-fish is fundamentally merely an involution.

The duct of the testes is, I have little doubt, derived from the anterior part of the Wolffian body; if so, it must be looked upon as not precisely equivalent to the Oviduct, but rather to a series of coalesced organs, each equivalent to the Oviduct. The Oviduct is in the Elasmobranchii, as in other vertebrates, primitively developed in both sexes. In the male, however, it atrophies. I found it still visible in the male Torpedos, though much smaller than in the females near the close of intra-uterine life.

Whether or not these theoretical considerations as to the nature of the Wolffian body and oviduct are correct, I believe that the facts I have brought to light in reference to the development of these parts in the Dog-fish will be found of service to every one who is anxious to discover the true relations of these parts.

Before leaving the subject I will say one or two words about the development of the Ovary. In both sexes the germinal epithelium (fig. 13) becomes thickened below the Oviduct, and in both sexes a knob (in section but really a ridge) comes to project into the pleuro-peritoneal cavity on each side of the mesentery (fig. 13, *p*, *o v*). In both sexes, but especially the females, the epithelium on the upper surface of this ridge becomes very much thickened, whilst subsequently it elsewhere atrophies. In the females, however, the thickened epithelium on the knob grows more and more conspicuous, and develops a number of especially large cells with large nuclei, precisely similar to Waldeyer's (loc. cit.) "primitive ova" of the Bird. In the male the epithelium on the ridge, though containing primitive Ova, is not as conspicuous as in the female. Though I have not worked out the matter further than this at present, I still have no doubt that these projecting ridges become the Ovaries.

[1] While correcting the proofs of this paper I have come across a memoir of W. Müller ('Über die Persistenz der Urniere bei Myxine Glutinosa,' 'Jenaische Zeitschrift,' vol. vii, 1873), in which he mentions that in Myxine the upper end of the Walffian duct communicates by numerous openings with the pleuro-peritoneal cavity; this gives to the suggestion in the text a foundation of fact.

The Head.

The study of the development of the parts of the head, on account of the crowding of organs which occurs there, always presents greater difficulties to the investigator than that of the remainder of the body. My observations upon it are correspondingly incomplete. I have, however, made out a few points connected with it in reference to some less well-known organs, which I have thought it worth while calling attention to in this preliminary account.

The continuation of the Pleuro-peritoneal Cavity into the Head.

In the earlier part of this paper (p. 346) I called attention to the extension of the separation between somatopleure and splanchnopleure into the head, forming a space continuous with the pleuro-peritoneal cavity (Pl. XIV, fig. 8 *a*, *p p′*); this becomes more marked in the next stage, and, indeed, the pleuro-peritoneal cavity is present for a considerable time in the head before it becomes visible elsewhere. At the time of the appearance of the second visceral cleft it has become for the most part atrophied, but there persist two separated portions of it in front of the first cleft, and also remnants of it less well marked between and behind the two clefts. The visceral clefts necessarily divide it into separate parts.

The two portions in front of the first visceral cleft remain very conspicuous till the appearance of the external gills, and above the hinder one of the two the fifth nerve bifurcates.

These two are shown as they appear in a surface view in fig. 14, *p p′*. They are in reality somewhat flattened spaces, lined by a mesoblastic epithelium, the epithelium on the inner surface of the space corresponding to the splanchnopleure, and that on the outer to the somatopleure.

I have not followed the history of these later than the time of the appearance of the external gills.

The presence of the pleuro-peritoneal cavity in the head is interesting, as showing the fundamental similarity between the head and the remainder of the body.

The Pituitary Body.

All my sections seem to prove that it is a portion of the epiblastic involution to form the mouth which is pinched off to form the pituitary body, and not a portion of the hypoblast of the throat. Since Gotte ('Archiv. für Micr. Anat.,'

Bd. ix) has also found that the same is the case with the Batrachians and Mammalia, I have little doubt it will be found to be universally the case amongst vertebrates.

Probably the observations which lead to the supposition that it was the throat which was pinched off to form the pituitary body were made after the opening between the mouth and throat was completed, when it would naturally be impossible to tell whether the pinching off was from the epiblast of the mouth involution or the hypoblast of the throat.

The Cranial Nerves.

The cranial nerves in their early condition are so clearly visible that I have thought it worth while giving a figure of them, and calling attention to some points about their embryonic peculiarities.

From my figure (14) it will be seen that there is behind the auditory vesicle a nervous tract, from which four nerves descend, and that each of these nerves is distributed to the front portion of a visceral arch. When the next and last arch (in this species) is developed, a branch from this nervous mass will also pass down to it. That each of these is of an equal morphological value can hardly be doubted.

The nerve to the third arch becomes the glosso-pharyngeal (fig. 14, *g l*), the nerves to the other arches become the branchial branches of the vagus nerve (fig. 14, *v g*). Thus the study of their development strongly supports Gegenbaur's view of the nature of the vagus and glosso-pharyngeal, viz. that the vagus is a compound nerve, each component part of it which goes to an arch being equivalent to one nerve, such as the glosso-pharyngeal.

Of the nerves in front of the auditory sac the posterior is the seventh nerve (fig. 14, VII). Its mode of distribution to the second arch leaves hardly a doubt that it is equivalent to one such nerve as those distributed to the posterior arches. Subsequently it acquires another branch, passing forwards towards the arch in front.

The most anterior nerve is the fifth (fig. 14, V), of which two branches are at this stage developed. The natural interpretation of its present condition is, that it is equivalent to two nerves, but the absence of relation in its branches to any visceral clefts renders it more difficult to determine the morphology of the fifth nerve than of the other nerves. The front branch of the two is the ophthalmic branch of the adult, and the hind branch the inferior maxillary branch. The latter branch subsequently gives off low down, *i. e.*

near its distal extremity, another branch, the superior maxillary branch.

In its embryonic condition this latter branch does not appear like a third branch of the fifth, equivalent to the seventh or the glosso-pharyngeal nerves, but rather resembles the branch of the seventh nerve which passes to the arch in front, which also is present in all the other cranial nerves.

Modes of Preparation.

Before concluding I will say one or two words as to my modes of preparation.

I have used picric and chromic acids, both applied in the usual way; but for the early stages I have found osmic acid by far the most useful reagent. I placed the object to be hardened, in osmic acid (half per cent.) for two hours and a half, and then for twenty-four hours in absolute alcohol.

I then embedded and cut sections of it in the usual way, without staining further.

I found it advantageous to cut sections of these embryos immediately after hardening, since if kept for long in the absolute alcohol the osmic acid specimens are apt to become brittle.

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Observations *on the* Development *of the* Pond-snail (*Lymnæus stagnalis*), *and on the* Early Stages *of other* Mollusca. By E. Ray Lankester, M.A., Fellow and Lecturer of Exeter College, Oxford. (With Plates XVI and XVII.)

§ 1.—Some of the Developmental Phenomena of Mollusca.

Four years since, I determined to make a study of the developmental phenomena of a series of Mollusca, with the view of ascertaining from the minute comparison of a number of cases what phenomena might be common to the group, or be considered as indicating ancestral conditions inherited from common ancestors.

The success which had attended Fritz Müller's investigation of the Crustacea, and his celebrated "recapitulation hypothesis," according to which we have, in the development of every individual organism, a more or less complete epitome of the development of the species, so that the series of changing forms passed through between ovum and adult form are but a series of dissolving views or portraits (often very much marred) of its line of ancestors—this, I say, led me to hope that materials might be found in the developmental history of the Mollusca for constructing their genealogical tree. During the past fifteen years but little has been done in the study of the embryology of the Mollusca, and it was therefore to be expected that the application of improved methods of investigation and new hypotheses would yield valuable results. The result of my study of the development of the Lamellibranch *Pisidium* and of the Gasteropods *Aplysia, Neritina, Tergipes* and *Polycera,* are now in course of publication elsewhere.

I have also, during this spring, completed the examination of the development of the Cephalopod *Loligo* from an early stage of the ovarian egg up to the escape of the embryo from the egg-jelly, which, together with less complete accounts of the development of *Octopus* and *Sepia,* I hope soon to see published. Before proceeding to give here an account of observations on *Lymnæus* which I carried out during July in the laboratory of Exeter College, Oxford, I may briefly summarise the chief results of my previous observations, which are remarkably confirmed by the facts to be subsequently related in regard to *Lymnæus.*

Kowalevsky, in his account of the development of *Amphi-*

oxus and of *Phallusia*, pointed out that the inner series of cells which give rise to the alimentary canal in those animals take up their position as the result of an invagination of part of the wall of an original multicellular sac. I found the same mode of origin for the primitive alimentary canal or endoderm of the Lamellibranch *Pisidium*, of the Pulmonates *Limax* and *Lymnæus*, of the Nudibranchs *Tergipes* and *Polycera*. This led me to compare the early development of members of other groups of the animal kingdom, the Planulæ of Sponges and Cœlenterates, the frog's embryo with Rusconian anus, &c., and I was thus led to infer that in this simple double-walled sac, composed of ectoderm and endoderm, we have the transitory indication of a primæval ancestor of all the higher groups of the animal kingdom, whose essential structure is permanently retained in the corals and polyps (Cœlenterata), but is in the course of development improved upon by the evolution of a body-cavity, and an additional third or intermediate mass of embryonic cells, giving rise to muscular and vascular structures in worms, molluscs, arthropods, star-fishes, and vertebrates. I proposed to call this developmental form the Planula, its immediate predecessor (the multicellular sac) a Polyblast, and indicated three large divisions of the animal kingdom—Homoblastica, Diploblastica, and Triploblastica—corresponding respectively to a lower stage than the Planula, to the Planula itself, and to a higher development of the essential Planula-structure.[1]

Almost simultaneously Professor Haeckel, of Jena, arrived at similar conclusions, which he first made known in his 'Monograph of the Calcareous Sponges,' and subsequently developed in the essay entitled "The Gastraea-Theory," which has been translated by Professor Perceval Wright for the April and July numbers of this Journal. The terms Gastrula and Gastraea, introduced by Professor Haeckel, are preferable to the term Planula which I had adopted; and I may further take this opportunity of admitting to some extent the justice of his criticisms on my use of the term Triploblastica. It appears to me more and more certain that (as he has definitely pointed out) the third layer, or those masses of cells which in the embryos of Triploblastica are regarded as belonging to such a layer, are phylogenetically derived either from one or other of the two primitive cell-layers, and only appear by suppression of the historical steps of development as an intermediate and independent layer. Nevertheless, the fact that they do so appear, and that there

[1] 'Annals and Mag. Nat. History,' June, 1873.

is a *third* plane of development really brought about by the formation of a body-cavity, seems to justify the use of the terms Diploblastica and Triploblastica. The latter corresponds essentially with Haeckel's Metazoa. With regard to the difference between Professor Haeckel and myself as to the relation of the body-cavity and the water-vascular system, I must at present maintain the view expressed in my essay. The difference is not so great as Professor Haeckel appears to believe. I do not accept his existing groups of acœlomatous worms as such, for in the Planarians and Cestods there appears to me to be evidence that the ramifications of the water-vascular stems are to be regarded as corresponding to a commencing body-cavity. The terminal portions of those stems, which open to the exterior, on the other hand, are, as I pointed out in the essay referred to, to be regarded as something distinct—an involution of the epidermic layer subsequently developing into the segmental organ. It does not by any means follow that the body-cavity is *primitively* open to the exterior, a view which Professor Haeckel has by misapprehension attributed to me. It will not, however, be useful to discuss this matter further without reference to renewed investigation of the facts.

A second and third phase in the development of the Mollusca, which have long been known, and which may or may not make their appearance in any particular case, are (what may be called) the Trochosphere and Veliger forms, the former an early condition of the latter. Both are well known and characteristic of various groups of Worms and Echinoderms, and the latter is seen in its full development in the adult Rotifera and in the larval Gasteropoda and Pteropoda. The identity of the velum of larval Gasteropods with the ciliated discs of Rotifera seems to admit of little doubt, and it would be well to have one term, *e.g.* velum, by which to describe both. The Trochosphere is the earlier, more or less spherical form in which the velum is represented by an annular ciliated ridge, and which is sometimes (*e. g. Chiton*) provided with a polar tuft of long cilia.

The cell, polyplast (morula), gastrula, trochosphere, and veliger phases of molluscan development are not distinctive of the molluscan pedigree; they belong to its præ-molluscan history. The foot, the shell-gland, and the odontophore are organs which are distinctively molluscan—the last characteristic of the higher Mollusca only—the other two of the whole group, and their appearance must be traced to ancestors within the proper stem of the molluscan family tree. The foot is essentially a greatly developed lower lip.

With regard to the shell-gland, which has not up to the present moment been recognised by any observers, my studies have yielded most interesting results. This organ appears to have a very wide distribution among the different classes of Mollusca, and to be present even in the most remote members of the group—the Polyzoa and Brachiopoda.

I do not propose here to give a detailed account of this

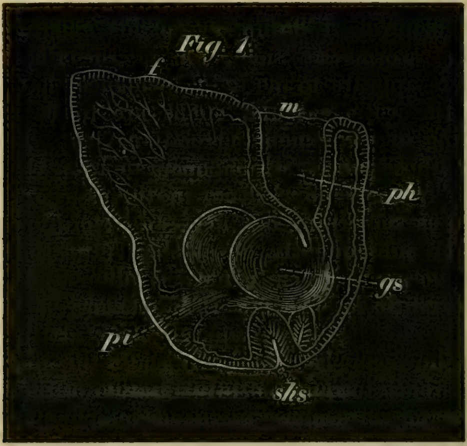

Diagram of an embryo of *Pisidium pusillum*. *f.* Foot. *m.* Mouth. *ph.* Pharynx. *gs.* Gastrula-stomach (now bilobed). *pi.* Pedicle of invagination (terminal intestine). *shs.* Shell-gland.

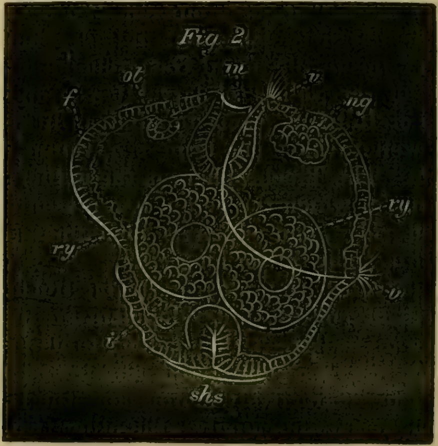

Diagram of an embryo of *Pleurobranchidium*. *f.* Foot. *ot.* Otocyst. *m.* Mouth. *v.* Velum. *ng* Nerve-ganglion. *ry.* Residual yelk-spheres. *shs.* Shell-gland. *i.* Intestine.

organ, but shall refer to the woodcuts (figs. 1 and 2) as illustrating its position and character in the embryos of *Pisidium* and of *Aplysia* (*Pleurobranchidium*) respectively. The gland (*shs*) under certain circumstances, connected with an arrest of regular development, becomes filled with a chitinous plug in the case of the *Aplysia* embryo. When at Messina, during May of this year, I found that Dr. Herman Fol had discovered the same shell-gland in embryo Pteropods, and, strangely enough, he had found the same plugging with a chitinous secretion in specimens abnormally developed. I have observed the same "shell-gland" in an early stage of *Neritina*, and, as will be seen below, it has a very well-marked development, accompanied by occasional plugging with a chitinous material, in *Lymnæus*.

The position of the gland in *Pisidium*, and its relation to the pair of calcareous valves which develop on either side of it, suggests that it may in the Lamellibranchs be represented in adult life by the ligament; but this connection I have not been able to demonstrate; on the other hand, in *Aplysia*, *Neritina*, *Lymnæus*, and the Pteropods, it certainly disappears—is, in fact, an evanescent embryonic structure.

One naturally turns, after detecting this organ in Lamellibranchs, Gasteropods, and Pteropods, to the classes which have been (I think a little invidiously) separated as Molluscoida from the other Molluscs—I mean the Brachiopoda and the Polyzoa—to see if in them any trace of the shell-gland can be found. I do not know, at the present moment, of any such organ having been as yet observed in the young stages of Polyzoa. But in a very strange form, which must be classed with the Polyzoa, there is such an organ, occupying exactly the required position.

Loxosoma neapolitanum was described first by Keferstein, and subsequently by Kowalewsky, from whose memoir the accompanying woodcut (fig. 4) is taken. The large gland of attachment (*shs*) appears to me to be very probably the homogen of the shell-gland. Further, in the Brachiopoda we have a gland developed at the same point in many forms, appearing at a very early stage in *Terebratula* and *Trebratulina*, and well known as enabling the animal to fix itself by means of its pedicle. The position of this gland corresponds accurately with that of the shell-gland in the embryo *Pisidium*, *Aplysia*, and *Lymnæus*. Hence I consider that we have evidence for considering this organ as one common to Polyzoa, Brachiopoda, Lamellibranchia, Gasteropoda, and Pteropoda.

A question which at once presented itself after the general presence of this organ had been ascertained was this—Does

it correspond in any way to the sac in which the internal shell of *Limax*, and, further, that in which the pen of the

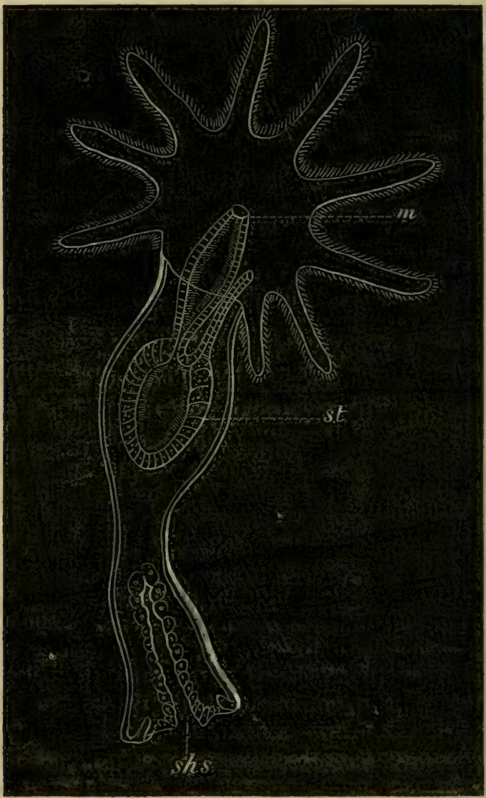

Diagram of *Loxosoma*. *m*. Mouth. *st*. Stomach. *shs*. Shell-gland.

Dibranchiate Cephalopods, is developed? These two heads of the question must be kept apart.

We know, among *Aplysia* and its allies, and, further, in *Spirula*, of *external* shells which have become internal, or, we should better say, *enclosed*, by the overgrowth of the surrounding folds of the mantel. That is apparently the individual history of the concealed shell of *Aplysia*, and probably is that of the concealed nautiloid shell of *Spirula* also; and, consequently, it may be inferred that such is also the genealogical history of those shells.

But the development of *Limax*, &c., has been sufficiently studied by Gegenbaur ('Zeitschr. f. Wiss. Zool.,' Bd. iii), and Schmidt ('Archiv f. Anatomie,' 1851), to show that

in these animals the shell is from the first formed in a sac. In fact, we should only have to retain the shell-gland of the allied pulmonate *Lymnæus*, in adult life, in order to produce precisely the required internal shell of *Limax*. It seems, therefore, very probable that the shell of *Limax* is identical with the plug of the shell-gland, which has so wide a distribution among the embryos of Mollusca. At the same time further knowledge of the development of *Limax* and other Pulmonata, is necessary for a satisfactory conclusion on this point.

The further question as to the identity of the shell-gland and its plug with the pen-sac and pen of the dibranchiate Cephalopods is of very great importance and great difficulty. Professor Gegenbaur, in his 'Grundz. der vergleich. Anatomie,' puts forward the view that the Cephalopoda, on account of their bilateral symmetry and general anatomical relations with the other Mollusca, are to be regarded as the least specialised group of the whole stock; that is, as more closely retaining the characters of the common ancestors of existing Mollusca than do any other forms. If this be so, we should expect to find a representative of the shell-gland in the organization of the Cephalopods, and our attention is immediately directed to the pen-sac and pen of the Dibranchiata. If the shell-gland and pen-sac are identical structures we have a brilliant confirmation of Gegenbaur's view. This was one of the chief matters to which I directed my attention in a recent study of the development of *Loligo*, *Sepiola*, *Sepia*, and *Octopus*. I was anxious to determine the exact mode of the first commencement of the sac in which the "pen" of these cuttle-fish develops. I have only space here to state that it makes its first appearance as a relatively very small circular pit, the sides of which close in above so as to form a shut sac, which enlarges and elongates with the later growth of the embryo. In fig. 3 is given a drawing of a section of a very young embryo (the drawing is cut off so as to omit the yelk-sac and give only the embryonic portion of the specimen) at a stage when the pen-sac is still open, and its lips commencing to close in. Its position and mode of development exactly agree with that of the shell-gland as seen in the other molluscan embryos figured in this paper. We are, therefore, fairly entitled to conclude, from the embryological evidence, that the pen-sac of Cephalopoda is identical with the shell-gland of other Mollusca.

But here—forming an interesting example of the interaction of the various sources of evidence in genealogical biology—palæontology crosses the path of embryology. I

think it is certain that if we possessed no fossil remains of Cephalopoda the conclusion that the pen-sac is a special

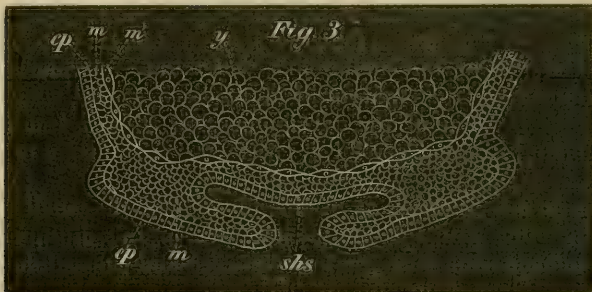

Diagram of vertical right-and-left section through mantle-region of an embryo *Loligo*. *ep*. Epiblast. *y*. Food-yelk. *m*. Mesoblast. *m'*. Deep-layer of cells (query, hypoblast) separating embryo from food-yelk. *shs*. Open pen-sac.

development of the shell-gland would have to be accepted. But the consideration of the nature of the shell of the Belemnites, and its relation to the pen of living Cuttle-fish, brings a new light to bear on the matter. Reserving anything like a decided opinion as to the question in hand, I may briefly state the hypothesis suggested by the facts ascertained as to the Belemnitidæ. The complete shell of a Belemnite is essentially a straightened nautilus-shell (therefore an external shell, inherited from a nautilus-like ancestor), which, like the nautiloid shell of *Spirula*, has become enclosed by growths of the mantle, and, unlike the shell of *Spirula*, has received large additions of calcareous matter from those enclosing over-growths. On the lower surface of the enclosed nautilus-shell of the Belemnite—the phragmacone—a series of layers of calcareous matter have been thrown down forming the guard; above, the shell has been continued into the extensive chamber formed by the folds of the mantle so as to form the flattened pen-like pro-ostracum of Huxley. Whether in the Belemnites the folds of the mantle which thus covered in and added to the original chambered shell were completely closed so as to form a sac or remained partially open with contiguous flaps must be doubtful. In *Spirula* we have an originally external shell enclosed but not added to by the enclosing mantle-sac. In *Spirulirostra*, a tertiary fossil, we have a shell very similar to that of *Spirula*, with a small guard of laminated structure developed as in the Belemnite (see the figures in Bronn, 'Classen u. Ordnungen des Thierreichs'). In the Belemnites the original nautiloid

shell is small as compared with *Spirulirostra*. It appears to be largest in Huxley's genus *Xiphoteuthis*. Hence, in the series *Spirula, Spirulirostra, Xiphoteuthis, Belemnites*, we have evidence of the enclosure of an external shell by growths from the mantle (as in *Aplysia*), of the addition to that shell of calcareous matter from the walls of its enclosing sac, and of the gradual change of the relative proportions of the original nucleus, (the nautiloid phragmacone,) and its superadded pro-ostracal and rostral elements tending to the disappearance of the nucleus (the original external shell). If this view be correct as to the nature of these shells, it is clear that the shell-gland and its plug has nothing to do with them. The shell-gland must have preceded the original nautiloid shell, and must be looked for in such a relation whenever the embryology of the pearly Nautilus can be studied. Now, everything points to the close agreement of the Belemnitidæ with the living Dibranchiata. The hooklets on the arms, the ink-bag, the horny jaws, and general form of the body, leave no room for doubt on that point; it is more than probable that the living Dibranchiata are modified descendants of the mesozoic Belemnitidæ. If this be so, the pens of *Loligo* and *Sepia* must be traced to the more complex shell of the Belemnite. This is not difficult if we suppose the originally external shell, the phragmacone, around which as a nucleus the guard and pro-ostracum were developed, to have finally disappeared. The enclosing folds of the mantle remain as a sac and perform their part, producing the chitino-calcareous pen of the living Dibranch, in which parts can be recognised as corresponding to the pro-ostracum, and probably also to the guard, of the Belemnite. If this be the case, if the pen of *Sepia* and *Loligo* correspond to the entire Belemnite shell minus the phragmacone-nucleus, it is clear that the sac which develops so early in *Loligo*, and which appears to correspond to the shell-gland of the other molluscs, cannot be held to do so. The sac thus formed in *Loligo* must be held to represent the sac formed by the primæval upgrowth of mantle-folds over the young nautiloid shell of its Belemnitoid ancestors, and has accordingly no general significance for the whole molluscan group, but is a special organ belonging only to the Dibranchiate stem, similar to—but not necessarily genetically connected with—the mantle-fold in which the shell of the adult *Aplysia* and its congeners is concealed. The pen, then, of Cephalopods would not represent the plug of the shell-gland. In regard to this view of the case, it may be remarked that I have found no trace in the embryonic history of the living Dibranchiata of a

structure representing the phragmacone; and further, it is possible, though little importance can be attached to this suggestion, that the Dibranchiate pen-sac, as seen in its earliest stage in the embryo *Loligo*, &c., is fused with the surviving remnants of an embryonic shell-gland. When a zoological observatory has been established in the southern seas, and the embryology of *Nautilus pompilius* worked out, we shall probably know with some certainty the fate of the molluscan shell-gland in the group of the Cephalopoda. By the use of no very great ingenuity it might be possible to conceive of the pro-ostracum alone of the Belemnite as being the plug of the shell-gland, and thus to save the homogeny of the embryonic pen-sac of living Cuttle-fish with the so closely corresponding sac (the shell-gland) of other Mollusca. I will only venture one additional remark of a speculative tendency here, and that is that the siphuncle of the chambered shells of *Nautilus* and *Spirula* is so placed as to suggest an inquiry as to whether it may have any relation to this problematical shell-gland.

The preceding discussions and speculations have been introduced with the object of rendering more clear the points of interest in the facts of the development of *Lymnæus stagnalis* which are recorded below.

§ 2.—Development of Lymnæus Stagnalis.

The well-known egg-jelly of the common pond-snail is to be found on water-plants in most ponds from June to October. The jelly encloses a number of tense capsules, each of which contains one, rarely two, eggs.

Many points of interest in the earliest stages of the deposited egg demand minute investigation with the highest power, and have been entered into in a suggestive rather than a conclusive manner by M. Lereboullet in his extended "Monograph of the Development of *Lymnæus*" ('Annales des Sciences Naturelles,' ser. iv, t. 18, 1862). I shall here only record a few facts tending to show the general disposition of the masses resulting from the segmentation of the primitive egg-sphere, reserving the consideration of the minute structure and relations of the various elements of the yelk for another occasion. The egg-sphere, as laid, has a diameter of about $\frac{1}{220}$ of an inch. By the middle of the third day from its deposition in the warm season it has assumed the form seen in Pl. XVI, figs. 8—12, and is then $\frac{1}{180}$ of an inch in diameter. The intermediate steps are not easy to follow with certainty. It is necessary by sharp

pressure or by needles to remove the egg from its envelope, to avoid anything like actual contact with it, and to study it with high powers (250 to 400 diameters) by both transmitted and reflected light. The egg is not a transparent one, and is very easily distorted by manipulation. Osmic acid solution of one per cent. is useful in the earlier but more especially in the later stages of the investigation, and enabled me to preserve specimens permanently.

Formation of the Gastrula.—With the first contractions of cleavage one or two pellucid drops are extruded from the brown yelk-mass, and remain adherent to the axial point of the egg, as in many other molluscs and worms; they are the well-known "Richtungsbläschen," and disappear, becoming detached at a later stage of development. They may serve a useful purpose for the embryologist if they enable him to recognise at any subsequent period when they are present the original pole at which they made their appearance. But it must be borne in mind that such droplets of albuminous matter are occasionally extruded from eggs of the same character as those of *Lymnæus* at other points during later stages in the process of segmentation of the egg-sphere. In Pl. XVI, figs. 2 and 3, lateral and polar views of the egg when exhibiting four divisions are given. In figs. 5 and 6 a series of smaller segmentation cells is seen extending itself so as to surround four larger spheres. The stage intermediate between this and the simple quadripartite form I have not yet observed, nor is it clear from M. Lereboullet's figures whence precisely these smaller cells arise. He figures an egg consisting of four large cells with four little ones surmounting them, but does not demonstrate whence these four smaller cells have originated. I have not seen the egg in this state. If we compare the case of *Aplysia* we find there a series of smaller cells growing over and enclosing two larger segmentation spheres, but the origin of these smaller cells is clear from the beginning; even in the unsegmented egg the pale transparent portion of the egg from which they are formed is distinguishable from the more granular opaque mass which forms the two large enclosed spheres. This is the first point of obscurity in the transition from fig. 3 to fig. 10. It can, no doubt, be readily cleared up by painstaking observation of a large number of eggs. In fig. 4 we have a lateral view of the same egg as that of figs. 5 and 6. The drawing is so placed that the smaller cells are below the large spheres above. This is for comparison with the succeeding fig. 7. At the pole of fig. 4 is seen a clear albuminous corpuscle, undoubtedly of the nature of Richtungsbläschen, sticking, as

it were, in the point of intersection of the sectors of the large yelk-masses. It is possible that this is *not* the same corpuscle as that seen in figs. 1 and 2. If it be the same we have this to observe — that whereas in *Aplysia* the Richtungsbläschen escapes from the paler pole of the unsegmented egg, where the smaller enveloping cells are formed, in *Lymnæus* the pole from which the Richtungsbläschen is detached does *not* exhibit the *more* active, but the *less* active, segmentation. Accordingly, the small cells in *Lymnæus* would appear *not* to correspond with the small cells in *Aplysia;* they are not advancing, in the case of *Lymnæus*, to enclose the four larger masses as they do enclose the two large spheres of *Aplysia*, but are growing in the opposite direction. In fig. 7, taking the position of the Richtungsbläschen and the general shape again as a guide, we find the larger cells still left unenclosed by the smaller, which are now sinking in on the lower surface to form the primitive alimentary canal of the gastrula-form seen in the subsequent figures. This interpretation depends upon the assumption of the constancy of the position of the Richtungsbläschen, and also on the marked agreement in form of the embryos when placed as drawn in figs. 4 and 7. If we might disregard this, and invert fig. 6, we should have what would appear to be a much more intelligible mode of formation of the primitive in-pushing of the gastrula of *Lymnæus*. Fig. 4 being inverted, we should, looking at it in the light of fig. 7, and disregarding Richtungsbläschen, see in this stage the gradual extension of the smaller cells over the larger, so as to enclose them, just as certainly does occur in *Aplysia*, and the in-pushing in the base of fig. 7 would be the final result of the growing over and approximation of the circumferential border of the cap of enclosing cells. Unfortunately the embryo or segmented egg-mass in the stage seen in fig. 7 is too opaque to allow of our obtaining evidence on this point from its actual structure. The question as to the *precise* mode of formation of this gastrula, and, indeed, of all gastrula-forms, is one of such very great interest at present that I have not kept silence about the difficulties which this has presented to me, though a little more time and care than I have given to this part of the developmental history of *Lymnæus* would settle the point.[1] In figs. 8, 9,

[1] M. Lereboullet's account does not help one very much in this part of the history. He figures one embryo as perfectly spherical and composed of "twenty equal spheres." I did not come across such embryos, but they would clearly be later than the stage given in fig. 4, and intermediate necessarily between it and the youngest gastrula-phase, namely fig. 7. In

10, 11, 12, we have various views of the gastrula of *Lymnæus*. In assuming this form the embryo gets rid of a very delicate envelope, which appears to be of a slightly viscid nature, and which, together with the Richtungsbläschen, is now lost. It is seen in a loose detached condition in the stage represented in fig. 7.

The gastrula of *Lymnæus* has been figured and described by Lereboullet, who takes the fossa and orifice of invagination for the rudiment of the adult's mouth. I believe, however, that this is a mistake, and that the orifice of invagination in *Lymnæus* closes up, as I have observed, in the gastrula of the Lamellibranch *Pisidium*, and in that of *Limax* and of *Polycera*, *Tergipes*, and *Doris*.

The Lymnæus-gastrula has the same curious cushion-like form as observed in the Nudibranchs. The orifice of invagination, in its most strongly marked period of development, is a long, trough-like depression, running from one side of the cushion towards the middle, and there sinking deeply into the substance of the mass. Accordingly, as it is turned this way or that, the extent and direction of the orifice presents apparent differences, which are, however, merely apparent.

The figures will give a more correct notion of these appearances than any description.

Besides, by Lereboullet, who did not appreciate its true character, the gastrula of *Lymnæus* has been figured diagramatically by Professor Haeckel in his Gastræa-theory. (See Pl. VII.)

I have elsewhere distinguished two classes of gastrula forms, according to the mode of their development, namely, "invaginate gastrulæ" and "delaminate gastrulæ," the latter forming by an internal movement of stratification in a mass of embryonic cells, and not by a process of involution. The Lymnæus-gastrula is clearly an "invaginate" one; but amongst invaginate gastrulæ we may distinguish those which are formed by emboly (the growth inwards of a number of small cells), and those formed by epiboly, in which large cells remain, as it were, stationary, and are grown over by smaller cells. These terms are adopted from Selenka, who has given a very valuable account of the development of *Purpura lapillus* in the 'Niederlandisches Archiv für Zoologie,' Bd. I, July, 1872.

I am obliged to leave for further inquiry the interesting

this there is certainly not much if any difference in the size of the component cells, those in the apex of the pyramid being only apparently larger on account of their prominence.

question as to whether the invaginate gastrula of *Lymnæus* forms by emboly or epiboly, or has an intermediate character.

The Trochosphere.—The orifice of invagination of the gastrula now closes up, and its shape commences to undergo a change due to the development of a kind of equatorial ridge, the earliest rudiment of the velum. At the same time the movements of rotation of the embryo commence. The phase in which there is as yet no trace of the mouth, and in which the gastrula's orifice of invagination has disappeared, is not figured in the plates accompanying this paper; but I may refer to Lereboullet's pl. xii, fig. 36, for a good drawing of that particular phase, though the French naturalist does not recognise the significance of his illustration, since he believes that the Gastrula's orifice becomes the mouth.

The movements of rotation in the embryo *Lymnæus* are caused by very short cilia, which it is not difficult to see even with a quarter-inch (English make), after the embryo has been treated with osmic acid. These cilia have entirely escaped M. Lereboullet, who says, "J'ai cherché en vain la cause de ce mouvement qu'on attribue généralement à des cils vibratiles. Je puis affirmer que ces derniers n'existent pas, et qu'ils ne se voient jamais, à aucune epoque de la vie embryonnaire, sur toute la surface de l'œuf."

With a No. 10 *à* immersion Hartnack the cilia can be observed, even in the early period, when rotation first begins; later they are obvious enough in the region of the velum.

The phase which the embryo now enters upon with a distinct circumferential ciliated band is that which I have designated in the introductory remarks above as the trochosphere. In the earliest of the forms referable to this phase (Pl. XVI, fig. 13) the embryo has a very peculiar outline when viewed from the oral pole, the ciliated band appearing to commence its development in connection with the two lobe-like outgrowths right and left of the mouth. The remaining figures on Pl. XVI give various views of later trochospheres. The movements of rotation are now very rapid, and vary around two axes at right angles to one another, so that it is difficult to get a correct notion of the actual superficial form of the embryo. The figures supply such information as I can give.

The changes in the histological elements of the embryo from the earliest gastrula-form (fig. 7) to the latest trochosphere are no less marked and important than the changes in

external shape. I am not prepared to give a detailed account of those changes, but can only draw attention to some general features.

The invaginated cells or segmentation-products, which form the endoderm or primitive alimentary sac of the gastrula, are not at first distinguishable through the walls of the widely excavated pyramidal embryo. But as the wide orifice narrows to a slit, the two sets of cells become clearly distinguishable, a result due, not merely to the clearing-up of the outer cells, but also to the gradual assumption of a specific character—globular form, dark granulation, and high refrangibility—by the invaginated cells. During the whole of the later development, as far as I have watched it in *Lymnæus*, the gastrula's endoderm-cells are undergoing modification, resulting at last in the separation of a pellucid material from a more superficial granular matter, which appears ultimately to give rise to a cellular network (Pl. XVII, fig. 22). The minute history of the changes in these cells would be an important matter to determine, since it appears that the history of other invaginated gastrula-endoderms is not so simple as one might suppose beforehand. They are by no means simple masses of formative protoplasm, which merely multiply by division, but appear in many cases to contain other elements analogous to the nutritive yelk (whence obtained is not clear), which in earlier stages have accumulated in each endodermal cell. Each endodermal cell then appears to play a part analogous to that of a whole ovum in its early stages, segregating and giving rise to new cells by endogenous formation. A process of this sort appears to go on in the gastrula-endoderm of *Pisidium* as well as in that of *Lymnæus*, and probably also in the "residual yelk-spheres" of Pleurobranchidium. An important histiological arrangement seen in the specimen (Pl. XVI, fig. 14) is the connection of the endodermal mass of cells with those forming the body-wall by means of long processes. This is seen again in a later phase in Pl. XVII, fig. 19. The processes appear to be actual filaments of the cell-substance of the endodermal cells.

In the trochosphere so far the shape is nearly spherical, excepting for the raised ciliated ridges, which together make a heart-shaped outline on the surface of the embryo, the indentation of the heart being occupied by the mouth.

The Veliger-phase.—In fig. 1 of Pl. XVII we have a somewhat more advanced stage, and in figs. 2, 3, 4, 5, 6, the definite Veliger-phase is attained. In the Veliger the area of the velum has a definite development, occupying relatively

the same position and having something of the same relative size as the wheel-apparatus of a Rotifer. Moreover, in the Veliger the foot takes on a large relative growth, so as to form a projecting lobe; at first it is simple, but soon becomes, what is exceedingly important, bilobed. This bilobed condition of the foot need but be carried a very little further than it is in the Lymnæus-veliger, and we should have the Pteropod-veliger, with fully developed velum and two epipodial "wings," such as I had the opportunity of examining last spring at Messina through the kindness of Dr. Herman Fol.

In fig. 1 some interesting features are exhibited which happened to be unusually well presented by the particular specimen from which the figure is drawn. The letter *g* indicates the spot at which the gastrula's orifice of invagination has closed up, and the delicate pedicle of tissue (*p i*) extending from this to the enlarged gastrula-endoderm-cells is the "pedicle of invagination," precisely similar to the pedicle formed in the same way in the Lamellibranch *Pisidium* (for an account of which I must refer to the forthcoming volume of the 'Philosophical Transactions'). The thickened superficial tissue to the left of the closed orifice of invagination is the shell-disc—the earliest commencement of the mantle area. This again will be seen from the woodcut (fig. 2) to have its equivalent in other molluscs, and has, indeed, been especially described by Paul Stepanof in his account of the development of the pulmonate *Ancylus fluviatilis*. The further development of this region has, however, escaped him and all other previous observers. It is as a pushing in from this shell-disc that the shell-gland to which I have referred in the introduction, and which is seen in Pl. XVII, figs. 11, 12, 13, 14, and 17, is developed.

The Shell-gland.—The shell-gland—a name which suggests itself merely from the position of the gland, and not from any necessary functional connection with the formation of the shell—was seen figured and described by Lereboullet in his account of the development of *Lymnæus*. Lereboullet accurately described it at one period of its growth as a hollow cone, truncated and closed at its deeper extremity. He regarded it as the anal portion of the alimentary canal, and consequently termed it the "anal cone." From this it follows that he had failed to detect, as his figures also show to be the case, the "pedicle of invagination" and the true commencement of the terminal part of the alimentary tract. If we follow the shell-gland through the various figures on Pl. XVII, in which, it appears, we shall find that occupying at one time a very

prominent position, and pushing its way right up into the central mass of gastrula-endoderm-cells, it subsequently dwindles, and very rapidly disappears *altogether*, as the shell forms and the mantle-area becomes raised up as a convex dome with margin distinctly projecting to form a rudimentary mantle-flap. The drawings (Pl. XVII, figs. 11, 12) represent the shell-gland in its most strongly marked condition, the conical lumen of the gland being filled by a highly refracting chitinous substance. Curiously enough, the cases in which this occurs appear to be abnormal. In a mass of eggs which have for the most part advanced to the stage seen in Pl. XVII, fig. 10, two or three may be found which have hung back, and have an abnormal proportion of foot, mantle-flap, &c., besides being much smaller than the further advanced normal specimens. Such retarded specimens frequently exhibit the condition of the shell-gland figured in figs. 1 and 12. Not only is there this plugging of the gland, but the commencing shell (not at this period calcified, but entirely of a horny composition) is thick and rough as compared with the normal shell of the same size, and sometimes the plug is united to the disc-like shell, so that the two can be picked out by careful teazing as a separate plate and handle. In the introductory remarks above I have referred to my observations on *Aplysia* (*Pleurobranchidium*), where I found a precisely similar condition accompanying a retarded development.

The Velar Area.—Let us now return to the velum for the purpose of tracing its development, and that of the velar area. It is an extraordinary fact that the existence of a velum in the embryos of Pulmonata has been denied, and its absence is at this moment mentioned in so authoritative a work as Bronn's 'Thierreich' as characterising the young stages of that group. Pouchet, who appears to have seen it in the trochosphere-phase of *Lymnæus*, and whose figures are copied in Bronn's plates, traces it to the free edge of the mantle, for the first rudiment of which he mistakes it. Lereboullet appears to have missed it altogether. The fact is, as will be seen from the figures in Pl. XVII, that it not only is well developed in the youngest stages of *Lymnæus*, but persists in an altogether exceptional way, and is actually *retained in the adult*, having become the lip-like masses which are known in *Lymnæus* as the "subtentacular lobes." The margin of the velum is easy to trace in the Veliger-phase of *Lymnæus* on account of the large, granular, epidermic cells of a yellowish-brown colour which compose it. When the embryo passes from the Veliger-phase to the definite molluscan

phase with creeping foot, with mantle-flap and eye-tentacles, the cilia no longer predominate on the velum, but it remains as a well-marked ridge swelling out into a pair of lobes, one on each side of the mouth, and terminating bluntly on each side at the back of the head (Pl. XVII, figs. 7 and 10).

At the same time during the Veliger-period in which the foot commences to assume a bilobed form, a conical eminence appears on each side within the heart-shaped velar area. These two eminences are the eye-tentacles, and rapidly grow so as to overshadow the margins of the velum. In this phase of the development, as the embryo rotates, it often presents itself in the position seen in Pl. XVII, fig. 6, in which the foot is stretched in front, and the velar area with the growing eye-tentacles, and the mouth placed centrally, complete the rest of the visible part of the Veliger. The dark coloured margin of the velum itself is seen forming a curious saddle-shaped cincture placed transversely. It is easy enough to demonstrate that the velum actually persists in adult life by comparing such embryos as figs. 7 and 10 with full-grown Lymnæi. The fact that some of the Pulmonata thus retain this larval organ in the adult condition is important, because, so far as I know, no other mollusc has been shown to do so; and, in fact, no other organism which possesses a velum in its younger phases of development, such as the Echinodermata, Nemerteans, Gephyreans, and Chætopodous Annelids, with the exception of the Rotifers. Parts of the prostomial region in some of the Chætopodous Annelida may perhaps be traceable to the larval velum, as are the sub-tentacular lobes of *Lymnæus*.

The retention of the velum and the strongly bilobed character of the young foot mark the Pulmonata as an archaic group of odontophorous Mollusca. The presence of these archaic features is in accordance with the generalisation that such features may be looked for in the fresh-water representatives of large sea-dwelling groups, other examples being found in the fresh-water Radiolaria, in *Hydra* and *Cordylophora*, and in the living Ganoid fishes.

Nerve-ganglion.—Within the velar area coincidently with the commencing development of the eye-tentacles a bilobed mass of cells commences to develop, apparently from a local multiplication of cells belonging to the epidermic layer. They form a conspicuous mass, and enter into connection with the pharyngeal mass (figs. 8, 17, 23 *ng*). This is the supra-œsophageal nerve-mass, and it is to be noted that its mode of development is identical with that which I have elsewhere described in *Aplysia*.

I have no details to record with regard to the development of the eyes; but with regard to the otocysts may draw attention to the fact that they are absent in the stages studied by me, though in a corresponding period of development in the Nudibranchiata they have attained a high degree of perfection. This I imagine may be explained by the relatively smaller importance of the auditory organ in the adult *Lymnæus* than in the Sea-slugs, and their near allies the free-swimming snails (Heteropoda).

Mantle-flap and lung.—In Pl. XVII, fig. 8, a stage in which the shell-gland has disappeared, and the shell itself (*sh*) is already projecting like a watch-glass from the aboral pole of the embryo, the edge of the mantle first becomes raised up and definitely emarginated. Following this through figs. 7 and 10, we find its rim becoming more and more detached or lengthened, until in fig. 18, on the right-hand side, a considerable space is overhung by this marginal flap. It is here that the lung develops as a simple recess covered in by the mantle-flap. In the specimen drawn in fig. 18 the rudiment of the heart is also seen (*h*), and other organs in connection with the enlarged border of the mantle, viz. the tubular dark-coloured body opening to the exterior (*n*), which I take to be the young kidney, and the prolonged delicate terminal portion of the alimentary canal, which still ends blindly (*cr*).

Alimentary canal.—The fact that the alimentary canal ends blindly in so late a stage of development as that of fig. 18 should have made clear to M. Lereboullet that he was wrong in interpreting the shell-gland as an anal cone; but it must be admitted that to follow out fully the development of the alimentary canal is exceedingly difficult, even as far as its general contour is concerned, still more so when a histological and histogenetic point of view is attempted. In fact, here, as in all the embryologies which have been attempted, the dark point is in connection with the middle portion of the alimentary canal. If we knew with certainty whence and how its cellular elements are developed in all types which have been studied, we should have little difficulty in reducing the facts of development of the whole animal kingdom to satisfactory order.

We have seen that there results from the gastrula-invagination an outer cellular body-wall, from the elements of which the epidermic and muscular structures of foot, velum, mantle, and shell-gland, develop, and an inner invaginated sac composed of larger cells, supported on a short pedicle (the cells

of which are *not* large and granular, but scarcely distinguishable), the pedicle of invagination.

The sac composed of large cells very early becomes constricted, so as to present two lobes, as seen in Pl. XVII, fig. 1. In looking at the figures in Pl. XVII it must be remembered that the specimens are often compressed, and that only an optical section or partial view can be given of the various parts; hence the mass of large cells (the gastrula-endoderm) is frequently distorted. The lobes appear at first to lie right and left, the pedicle being in the median plane.

The pharynx now commences to develop with the in-pushing of the mouth from the body-wall, and gradually extends downwards into the mass of endoderm-cells, so as to be partly concealed by them (figs. 8, 11, 17 *ph*). At the same time the cells in the pedicle of invagination differentiate. The pedicle assumes a tubular character, and its parietal end becomes bent round, so that the tube terminates as a shortly reflected cæcum. Whilst the pharynx and the intestinal portion of the alimentary canal are thus differentiating, changes have been going on in the gastrula-endoderm-cells, to which changes I have already alluded. In place of a bilobed group of large granular cells we now have a net-work of fine granular filaments with nuclei at intervals completely enclosing and surrounding on all sides pellucid, highly refracting spheres (fig. 22). Moreover, a tunic of fusiform cells, of the same character as the elementary muscular cells which are seen in other parts of the embryo, has spread itself over the whole of the alimentary tract (fig. 17, *tge*). They are closely fitted to the pharynx and rectum (figs. 21, 22), and also extend over the pellucid spheres and their granular network, whence they send branches to the similar cells lining the body-wall (figs. 17, 22). Whence has this tunic developed? At the pharyngeal end the cells are clearly continuous with those of the body-wall, and at the rectal end also; but those enclosing what was the gastrula-endoderm are probably developed from the processes which the invaginate gastrula-cells send to the body-wall, even in the trochosphere stage of development, as seen in Pl. XVI, fig. 14. If this is the case the musculature of the terminal portions of the alimentary canal will have been developed, like the musculature of the body-wall, from the ectoderm of the gastrula, whilst the musculature of the middle portion of the alimentary canal and its appendices will have been developed from the gastrula's endoderm.

We have, however, yet to see what eventually comes of

this middle group of cells—the histologically changed, but in coarser features unchanged, bilobed group which formed the gastula's stomach. I have failed to penetrate to the centre of this mass of cells in earlier phases, and can, therefore, not explain how the structure to be described comes about. What can be observed is this, that as soon as the pharynx and its appendix, the odontophore's sac, becomes well marked, and the tubular structure with epithelial lining in the pedicle of invagination is clearly visible, then a little compression and manipulation renders clear the continuation of a tube-like structure with walls formed of small cells from pharynx to intestine, traversing the mass of large pellucid cells (Pl. XVII, fig. 21). This tubular structure is undoubtedly to be regarded as the so-called stomach of the adult *Lymnæus*. The metamorphosed gastrula-endoderm-cells now lie on each side of it as a pair of grape-like bunches, and long after it has become well-defined these two agglomerations of pellucid spheres, with their enclosing network and mesoblastic coat (the tunic of fusiform cells), remain. They are apparently eventually *absorbed* as nutritive matter by diverticula of the alimentary canal, which give rise to the liver, they themselves not giving rise subsequently to any permanent tissue. Now, it is a most important question whether the cell-elements which build up the so-called "stomach" (the middle piece of the alimentary canal) arise in any way from the large gastrula-endoderm-cells, or from the pharyngeal in-pushing, or from the intestinal pedicle of invagination. If from this last, they would just as much, as if they arose from the material of the central mass of gastrula-endoderm, be traceable to the invaginated cells of the gastrula-phase. On the whole, it seems probable that this is their origin; but the matter is still obscure. The analogy of other Mollusca does not take us very far towards a clearing up, for in all cases that I have studied the exact mode of origin of the middle portion of the alimentary canal is equally obscure. It is, however, interesting and of considerable importance for a true understanding of the matter, to note that in this case of *Lymnæus* we have a large proportion of the material which at one time formed the wall of the gastrula-stomach left outside the permanent alimentary canal and absorbed as a kind of food-yelk. The case of *Pleurobranchidium,* of which an embryo is represented in the woodcut, is, in a measure, parallel to this, for the two large nucleated spheres (*ry*) are that portion of the original cleavage-product of the egg which are overgrown or invaginated by epiboly. Hence they represent the gastrula-stomach, and, as in *Lymnæus,* a middle intes-

tine appears *between* them without our being able to determine whence it takes its origin; possibly it is from some of the material of these very cells, but they remain unembraced by the walls of the alimentary canal so formed, and gradually dwindle by the absorption of their material. In *Pisidium,* again, we have in the earlier condition a still closer agreement with *Lymnæus,* for there a very definitely marked, bilobed gastrula-stomach is formed by invagination (see woodcut, fig. 1). But in *Pisidium,* too, after this epoch, a great change comes over the cells forming the wall of the gastrula-stomach, its cavity becomes constricted, narrowed, and contorted, and apparently a new mid-portion of the alimentary canal is formed with separation of nutritive and formative elements from the original gastrula-endoderm-cells. Therefore it seems that the history of the development of the gastrula-stomach into the permanent middle intestine is by no means a simple one. It, in fact, involves the whole question of the part played by the so-called nutritive elements of the original egg-yelk, and we may expect gradations between the developmental processes of a simple unencumbered egg-cell (free from yelk-granules), such as that of the Nematoid *Cucullanus* (in which I should anticipate that the primitive alimentary canal would be directly enlarged so as to form the adult one), and those of the eggs of Cephalopods and birds, in which the egg-cell is well-nigh lost in an excess of superadded nutrient material.

Wherever these nutritive yelk-elements come in they derange and obscure the usual processes of cell-growth; in the earliest stages they give a paradoxical twist to the multiplication by fission of the primitive egg-cell, later to the mode of formation of the hypoblast or gastrula-endoderm, and finally, to the mode of development of middle intestine and liver from this last, whilst they may even have something to say to the development of other organs in which their too ready offer of nutritional assistance is accepted.

The later development of the alimentary canal, the breaking through of the anus to the exterior, and of the pharynx to the stomach or middle intestine, I have not followed, nor have I observed the development of the liver and absorption of the two masses of pellucid cells which Lereboullet has described, since I have not pursued the embryos to that phase. I may, however, here mention that in the Cephalopod *Loligo* I have determined, by means of transverse and longitudinal sections, that the great mass of "unorganised" yelk enclosed by the embryo is in that animal gradually absorbed, whilst the growth of a pair of diverticula from the alimentary

canal proceeds, which diverticula penetrate the unorganised yelk, and, filling up the position once occupied by it, become the two lobes of the Cephalopod liver. This process is probably a general one throughout the animal kingdom, with variation in non-essentials.

Muscular layers and muscles.—I have above spoken of fusiform cells arranged as a layer on the inner surface of the body-wall, and as surrounding the alimentary canal and bilobed mass of pellucid cells. These represent the mesoblastic elements of the embryo. I have not been able to find in the early stages of *Lymnæus* a layer or group of undifferentiated embryonic cells lying definitely between the gastrula's body-wall and stomach; such a layer would be a mesoblast. It is possible that there are some such loosely placed cells during a particlar phase of the development, just as there are in *Pisidium*, but they are derived either from the enclosing ectoderm or the invaginated endoderm in the first instance. The appearances are strongly in favour of the fusiform cells which lie in apposition to the epidermic cells of the body-wall, being derived from ectoderm or epiblast cells. The most noticeable groups develop at the circumference of the shell-gland (Pl. XVII, fig. 8 *mu*). The processes which pass from the gastrula-endoderm-cells to the body-wall appear (fig. 19), eventually to become muscular, but whether they should then be attributed to the latter or the former is doubtful. The term Triploblastic is applicable to *Lymnæus* and to other molluscs in which there is no definitely constituted layer intermediate between the gastrula's ectoderm and endoderm, since in it and them, as in all the groups filiated to Vermes the musculature has not only relations to the outer world and to the gastric space, but to a third interposed space—the hæmolymph cavity—in which a vascular system and blood-lymph spaces develop.

It is clear (and in saying this I am qualifying, though not recalling, what I have stated in my essay in 'Ann. and Mag. Nat. History,' June, 1873) that a mesoblast or third intermediate layer must *either* be derived from epiblast or hypoblast (either or both), and so cannot be spoken of as of coordinate value with those two layers; *or*, on the other hand, it must be a separate entity originating simultaneously with the epiblast and hypoblast from the egg-cell or its segmentation products. The latter case is one which certainly has not been usually contemplated in the use of the term "mesoblast" or "middle layer," and there is very small warrant for assuming it as expressing the historic or phylogenetic mode of origin of the layer in question. It is possible that

in some cases, when the gastrula's ectoderm and stomach-wall are differentiated by invagination, a certain number of the primitive segmentation-cells should remain involved, neither in the one nor the other, but lying intermediately, thus forming a simultaneously differentiated mesoblast, but even then we should be able to trace such cells to an earlier connection with the cells of either epiblast or hypoblast. In point of fact, such cases have not been brought forward from actual observation for discussion.

Thus, then, the term mesoblast and its correlative term "triploblastic" have not reference to the existence of an embryonic layer of co-ordinate value with the two primary layers, but to a disposition and growth of some of the early structural elements of the higher animals in and around a strongly marked space separating the two primary layers.

Summary.—The observations of fact which have been brought forward above are to a large extent disjointed, and even as far as concerns the period of development to which they refer, very far from exhaustive. They must rather be regarded as suggesting the desirability of more detailed and long-continued study.

As evidence of the value which may be assigned to them, I shall quote the summary of the development of the water-Pulmonata, given by Keferstein in Bronn's invaluable 'Thierreich,' followed by a statement of the points in which my observations traverse or supply important omissions in that summary.

Keferstein says (p. 1230 of the third volume of the above-named work):

"The Pulmonata of fresh waters exhibit the closest agreement with the Prosobranchiata, excepting that in them *all trace of a velum is wanting* (A). We possess very numerous and elaborate memoirs on the development of *Limnæus*, especially by Stiebel, Dumortier, Pouchet, Karsch, Warneck, Lereboullet, &c.; on that of *Planorbis* we have the researches of Jacquemin, &c.; so that the facts are here accurately known. We confine ourselves in the following remarks to *Limnæus*.

"Two hours after the egg is laid its cleavage commences, as a consequence of which at once one or two so-called Richtungsbläschen are pushed out by the contraction of the yelk, and then a first circumferential cleft extends itself round the spherical egg-mass. The germinal vesicle is no longer visible in the impregnated yelk; but shortly before the equatorial cleft is formed a clear speck is visible in the yelk, which, according to Warneck, becomes biscuit-shaped, and

finally divides into two clear specks, of which one is found in each half of the cleft yelk-mass. These clear specks are undoubtedly true nuclei of the cleavage spheres, but no connection between them and the germinal vesicle could be demonstrated. These nuclei divide again, and at the same time the yelk is seen to fall into four masses by the formation of a second cleft. According to Lereboullet all the cleavage-spheres fuse themselves into a homogeneous mass before each new segmentation every time, and then separate again and commence the process of further cleavage. According to Quatrefages the same thing occurs in the annelid *Sabellaria.* From the midst of four cleavage-spheres so formed and lying in one plane arises now a clear vesicle, which quickly divides into four small nucleated spheres, and soon both the four large and four small spheres—always preceded by their nuclei—again divide, so that the egg now consists of sixteen nucleated cleavage-spheres (B). The large spheres overgrow now with their progeny the smaller, and we have at last a spherical mass, which consists externally of large, internally of small cleavage-spheres, accordingly exactly the reverse of what occurs with the cleavage-spheres of the Opisthobranchiata and Prosobranchiata (C). Finally, however, the segmented egg consists of large nucleated cells ·02 to ·025 mm. in diameter, which do not as yet present any cell-membrane.

"At the end of the second day modifications of this cell-mass are seen. On one side the cell-mass hollows itself out, then flattens itself, and at the same time the in-sinking narrows its area, so that the mass presents a cavity within and a narrow emarginated opening leading into it. These are the alimentary cavity and the mouth (D); the outer cells are still larger than the inner ones. Beneath the mouth the body now flattens itself out and forms a process—the foot, and the embryo begins now its well-known and—since the time of Leuwenhoeck—celebrated slow movements of rotation. This rotation must be ascribed to cilia; but they are so fine that they have not been seen in *Limnæus,* although one may suppose by analogy that they exist especially on the foot (E). The foot grows more and more prominent, and the body becomes partially embraced by an annular ridge, in which the later mantle-margin is soon recognised (F). From behind now—over against the mouth—a new in-sinking is formed, anus and rectum, which grows up against the primitive alimentary cavity, and finally unites with it (G). The alimentary tract now becomes hollowed out, and in its neighbourhood large yelk-spheres are formed, the first rudiments of the liver (H).

"As yet the alimentary tract traverses the body almost in a straight line (I); but, now as the body becomes more elongated and cylindrical, it begins to bend on itself, and the anus takes up a position forward on the right-hand side. At the same time the mantle-margin grows greatly, and the hinder part of the body rises up in a dome-like fashion. On it one can now observe the small cap-like shell (*g*), and in the body a to-and-fro circulation, such as is seen in a much more marked manner in the land Pulmonata.

"The foot forms now a prominent bilobed process, and above it near the mouth, which also begins to push forward in a snout-like fashion (K), the tentacles are seen, and at their bases the eyes. The mantle ridge arches now more and more widely forward and raises itself up, so that we can now clearly distinguish a lung-chamber, in which ciliary movement is observed; also the heart is recognised by its contractions in the middle line behind the mantle-ridge.

"In the neck region the first rudiment of the nervous system is now seen (L), whilst the foot grows considerably, as also the shell-bearing hind-body.

"In the pharynx the commencement of the odontophor is seen, and in the further developed lung-chamber the kidney. Upon the eye-pigment a lens is now clearly seen, and now, at last, according to Lereboullet, the otocysts make their appearance, which in most snails appear in a much earlier stage.

"At first the otocysts are empty, but gradually the otoliths are secreted, and cilia appear on the walls of the sacs.

"The embryo is now so large that it fills up the egg-shell, and soon breaks it and creeps out. The rate of development varies much, according to temperature, but lasts at least twenty days, and may take double that time."

In reference to the passages lettered in the preceding quotation, the observations recorded in this paper lead to the following corrections:

A. The velum is not wanting in the freshwater Pulmonata; in its earlier annular and in its later heart-shaped form it is well developed, and becomes the subtentacular lobes of the adult Lymnæus.

B. The origin of the four smaller cells from a single pellucid cell, coexisting with four larger cells, is not satisfactorily demonstrated, such a single pellucid cell being possibly only a Richtungsbläschen.

C. Nor is the enclosure of the smaller by the larger cleavage-spheres clearly made out, though possible enough.

D. The in-sinking and its orifice are not the alimentary

cavity and mouth, but the gastrula-stomach and orifice of invagination; the latter closes up, and the pedicle so formed becomes the rectum, which terminates *blindly*.

E. With a good English quarter, or, better, with Hartnack's 10 immersion, and the use of osmic acid, the cilia which cause the rotation may be seen. They are disposed on an annular band, the commencing velum.

F. The annular ridge has nothing to do with the mantle's margin, but is the velum.

G. The new in-sinking has no connection with the anus or rectum, which latter already is taking shape in the pedicle of invagination. It is the "shell-gland," a structure common to many embryo mollusca, but hitherto unrecognised.

H. The so-called large yelk-spheres are not now first formed, but have been there all the time, forming the wall of the invaginated gastrula-stomach. They now undergo important segregative changes, and present the appearance of large clear globules, covered in by a fine granular reticulum.

I. The alimentary canal is from the first bent, the cæcal termination of the rectum lying a little forward, and not opposite the mouth.

J. The shell, as an exceedingly delicate membrane on the surface of the shell-patch (in the centre of which lies the shell-gland), is observable long before this.

K. The mouth never pushes forward, but rather becomes sunk and enclosed by the increasing development of the border of the velum, where it overhangs the mouth. This part of the velum forms the subtentacular lobes of the adult.

L. It can be seen at a very much earlier period.

A NOTE *on* ENDOTHELIUM. By JOHN CAVAFY, M.D., Assistant-Physician and Lecturer on Physiology at St. George's Hospital.

IN the last number of this Journal[1] there is a paper by Dr. M. Foster, "On the term Endothelium," in which he gives various reasons against the further use of this word in histological terminology. He objects to the word, both because its etymology is "of the most grotesque kind," and also on far more important anatomical grounds.

Much that is brought forward by Dr. Foster is, doubtless, true; but some portion of his statement must, I think, be

[1] 'Quart. Journ. of Mic. Sci.,' 1874, p. 219.

admitted to be mistaken, and he has completely passed over some important reasons which exist for maintaining the separate terms originally proposed by His.

In the first place, the word is not quite so ridiculous, etymologically, as it is represented to be by Dr. Foster. The word *endothelium* is obviously a contraction of *endo-epithelium*, and means an epithelium which is within (ἔνδον or ἐντὸς, *intus*) or internal, *i. e.* it means precisely what His intended to signify, and is only so far a misnomer as (epi)-thelium is concerned, since it covers "surfaces of which one great characteristic is that they are devoid of papillæ;" but, as Dr. Foster says, this extension of the meaning of Ruysch's original terms *epithelis* (of which *epithelida* is the accusative case) and *epithelia* "may be easily allowed." Endothelium does not mean "that which is inside a papilla" any more than *entoderm* means "that which is inside a skin;" *endoplast*, "that which is inside a formation;" or even *entozoon*, "that which is inside an animal." The real meaning of these terms Dr. Foster will, doubtless, admit to be "an *internal* skin, formation (nucleus), and animal." The etymological objections, therefore, do not hold.

Let us now consider, shortly, whether the physiological differences between epithelium and endothelium are sufficient to warrant the use of separate terms.

Dr. Foster says that endothelium cannot be employed to denote the epithelium derived from the mesoblast, "for it would then include structures still called epithelium, and differing in no essential characters from the epithelium derived directly from the hypoblast." But we should not forget that the mesoblastic origin of genito-urinary epithelium may be more apparent than real. Waldeyer[1] has suggested that its real origin is most probably from cells of the epiblast, which have become mixed with those of the mesoblast at the time of the formation of the primitive groove. This view is not, of course, susceptible of actual demonstration; but it is known, at any rate, that the mesoblast becomes closely fused with the epiblast in the region of the axial cord of His, and then again separates; and that it is after this separation that the Wolffian and Müllerian ducts are formed. It is therefore quite possible that the cells lining these organs and their derivatives may be really derived from the epiblast. Physiologically, at any rate, they are true epithelium, and not endothelium, *i. e.* they are concerned with *secretion*, which is never the case with endothelium. The small quantity of fluid which bathes the surface of serous

[1] 'Eierstock und Ei,' pp. 113—114.

and synovial membranes is a filtration or transudation, not a true secretion in the ordinary physiological sense of the word, for endothelium never forms glands, whereas a share in gland-formation, and, consequently, secretion, is a constant characteristic of epithelium, whether derived from epiblast or hypoblast.

As Dr. Foster says, continuity "affords no argument whatever for classing . . . . together. We find continuity everywhere." But in the case of endothelium we find in one most important instance, not only continuity, but something more. What takes place in the growth and development of capillary blood-vessels and lymphatics? We have in each case a vacuolation and excavation of connective-tissue-corpuscles, whose protoplasm becomes ultimately changed into endothelial plates, and we may find every transitional form between a flattened connective-tissue-corpuscle occupying the lymph canalicular system and the endothelium forming the wall of the lymphatic vessel with which it communicates. We have here, therefore, to do with *convertibility* as well as continuity; and if Dr. Foster admits that the connective tissues form a natural group derived from the mesoblast, of which convertibility of one member into another (well seen in pathological conditions) is one of the most striking characteristics, I do not see how he can exclude endothelium from a very close connection and relationship with the members of that group. In fact, the most recent researches on connective tissues have established a nearly complete identity between endothelium and connective-tissue-corpuscles, and this identity is strikingly evidenced by the close similarity of the pathological changes which they both undergo.[1]

Now, in the case of epithelium, not only has no such connection with connective tissues been observed, but there are marked differences between their respective pathological changes. The views of Heidenhain as to the continuity of the cylindrical epithelium covering the villi of the small intestine with branched connective-tissue-corpuscles in the stroma have been rendered more than

[1] "Les cellules du tissu conjonctif sont plates, contiennent des noyaux plats, et sont simplement appliquées sur les faisceaux du tissu conjonctif. Il serait complètement impossible de reconnaître une cellule endothéliale isolée de la plupart des cellules du tissu conjonctif."—Ranvier, art. "*Epithélium*," 'Nouveau Dictionnaire de Médecine,' vol. xiii, p. 687.

"Les altérations des séreuses . . . présentent une analogie complète avec celles du tissu conjonctif."—Cornil and Ranvier, 'Manuel d'Histologie pathologique,' p. 456.

doubtful by the important observations of Mr. Watney[1] on intestinal absorption, which he has shown to take place, not through the epithelium itself, but by pseudo-stomata formed by processes of connective-tissue-corpuscles, which project between the epithelium, with which they are never anatomically continuous.

We have, then, in the case of endothelium, not only an undoubted mesoblastic origin, but a close relationship with connective tissues; its cells, moreover, never form glands nor secrete. Epithelium, on the other hand, has a doubtful derivation from the mesoblast; gland-formation and secretion are among its most constant and striking characteristics, and it has absolutely no relationship with the connective tissues. Notwithstanding, therefore, Dr. Foster's statement (p. 292) that, "In short, there is no reason why the cells spoken of as forming endothelium should have a common title, distinct from the general term epithelium," I must confess that I am not convinced, but think that the reasons I have given above are sufficient to render the use of separate terms at least opportune—"im Interesse physiologischen Verständnisses."

Description *of an* Apparatus[2] *for* Maintaining *a* Constant Temperature *under the* Microscope. By E. A. Schäfer, Assistant-Professor of Physiology in University College, London.

The necessity of having the means of conveniently, but at the same time accurately, maintaining objects, especially the living tissues, under observation at a uniform temperature (generally that of the body) becomes more obvious every day. The existing methods of effecting this are, as a rule, not sufficiently accurate for exact investigations; and, on the other hand, the more accurate modes are frequently inconvenient of application. For example, the apparatus described by Stricker and Burdon-Sanderson in this Journal for 1870,—although it is possible by its aid to maintain a constant temperature under the microscope for a considerable time,—yet requires that there should be a vessel of water constantly boiling near the observer, and that the water in this vessel should be maintained at a uniform level, necessitating a supply tube from a cistern, and

[1] 'Proc. Roy. Soc.,' vol. xxii, p. 293.
[2] Made for me by Mr. Casella, of 147, Holborn Bars.

an overflow tube to a waste pipe. Moreover, since the temperature of the stage is regulated by the rate at which the heated water is allowed to flow through it, and this again is made to depend upon the difference of level between the orifice of the exit tube which leads from the stage and the height of the boiling water in the reservoir, and since this requires a rather complicated screw mechanism accurately to adjust the level for different temperatures (not to mention the numerous india-rubber tubes requisite for connecting the various parts of the apparatus), it is evident that, although the apparatus in question may be well enough adapted for a laboratory, it is less applicable to individual and private work. The apparatus to be here described, the main principles of which are a constant *circulation* of water and the introduction of a gas regulator, will, it is believed, be found simple and convenient in application, and capable of maintaining with almost absolute constancy any desired temperature for an indefinite time.

The apparatus consists of a closed brass box, oblong in

FIG. 1.

FIG. 1.—*a.* View of warm stage with inlet and outlet tubes, unconnected with heating apparatus. *c.* Horizontal section of stage, showing the manner in which the thermometer is passed into the central chamber, and the direction of the current of water in the stage.

form (fig. 1, *a*), which rests upon the stage of the microscope, a cylindrical chamber (fig. 2, *b*, in vertical section) being left in the centre of the box for the transmission of light from the mirror to the object (as in Stricker's warm stage). From each end of the box a tube passes (inlet and outlet), and the tubes are connected the one to the other by india-rubber tubing, so that there is thus formed a closed circuit, which, when the apparatus is ready for working, is entirely filled with water. A vertical reservoir (fig. 2, *c*), of not much greater capacity than an equal length of the connecting tube, is interpolated in the circuit at a point not far from the inlet of the stage, in such a manner that the upper end of the reservoir is connected with the inlet tube, the lower end with the outlet. The reservoir surrounds the bulb of a mercurial gas regulator (fig. 2, *d*; and fig. 3), and is heated below by a minute gas flame; it will be readily understood that the heated water in the reservoir must rise up through

the inflow tube into the stage, while the colder fluid passes into the reservoir through the lower tube to supply its place.

FIG. 2.

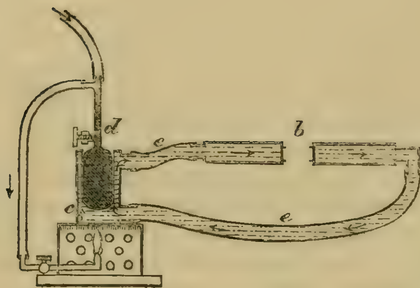

FIG. 3.

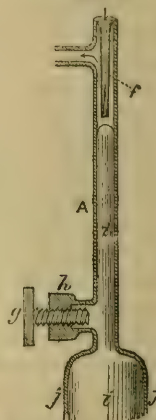

FIG. 2.—Ideal section of apparatus. *b.* Central chamber in stage. *c.* Vertical reservoir heated by small gas flame below, and enclosing bulb of mercurial regulator, *d.* *e, e.* Connecting tube of india rubber. The arrows show the direction of the gas in the regulator and of the currents of water in the heating apparatus respectively.

FIG. 3.—Gas regulator, about natural size. *j, j.* Upper part of bulb (rather small in proportion). A. Tube with side openings, to the lower of which is attached the steel collar *h,* in which works the screw *g.* *f.* Small steel tube with slit. *i, i.* Mercury. The arrows show the direction of the gas.

The chamber in the centre of the stage is, when in use, closed below by a circular cover-glass, which is placed on a rim made for its reception, and previously oiled; above, it is covered by the cover-glass, on which the object is placed; it communicates, however, with the exterior by means of a small lateral tube which passes through the body of the stage, but is entirely shut off from the surrounding fluid. The bulb of a small thermometer may be introduced through this lateral tube whenever it is wished to ascertain the temperature of the central chamber (see fig. 1, *c,* in horizontal section). This method of measuring the temperature has a considerable advantage over that in which the thermometer-bulb encircles the wall of the chamber and lies in the surrounding fluid, for this last is always very perceptibly warmer than the interior of the chamber. It has the dis-advantage that observations cannot be made while the thermometer is *in situ,* but this can be met by slightly withdrawing the instrument into the lateral tube. Indeed, ordinarily it will be sufficient, when the desired temperature is attained

and the regulator set, to remove the thermometer altogether; the lateral tube may then serve, if necessary, for the introduction of a small tube conducting gas or vapour to the specimen under observation.

The gas regulator may be described as a mercurial thermometer with its tube open above, and with two side tubes leading from it, one near the bulb, the other near the top (fig. 3). To the lower side tube is cemented a steel collar (*h*), in which a screw of the same metal accurately fits; by working this screw the mercury may be raised or lowered in the thermometer tube. A fine steel tube (*f*), with a slit at its lower end, passes down a certain way into the thermometer, being cemented around its upper orifice. The gas is made to pass down this fine steel tube, and then up between it and the walls of the thermometer tube; finally, it is conducted out by the upper side tube, and by means of india-rubber tubing to the burner below (as indicated by the arrows in figs. 2 and 3).

To "set" the regulator, when the central chamber of the stage has attained the desired temperature, all that is necessary is to turn the steel screw until the mercury is forced up to the slit in the steel tube; the gas is now cut off, except what can pass through the slit, and the flame is consequently very small; the temperature of the water in the reservoir consequently tends to be diminished, and the mercury in the thermometer tube to fall, but the moment this commences more of the slit becomes uncovered, more gas passes through, the flame is increased, and the temperature re-established. It is easy to understand that if the steel screw below is withdrawn somewhat, the mercury will not rise up to the slit, and will not therefore cut off the gas until the temperature of the water has risen proportionately higher than before. By screwing out or in every needful variation of temperature of the water in the reservoir, and through this of the stage, may, as before said, be obtained.

It is easy to fill the closed circuit before described—consisting of the reservoir, the stage, and the connecting tube of india-rubber—with water (which should have been previously boiled and allowed to cool), and once filled it will remain so, provided the india rubber be securely "wired" over the metal so as to exclude the possibility both of leakage and of the admission of air. The india rubber will, of course, readily adapt itself to the varying volume of the fluid, consequent on the changes of temperature to which it is exposed. It is important to employ as wide india-rubber tubing as the metal tubes will allow, so that no obstruction may be offered to the free circulation of the water.

In the first experiments the gas regulator, which in that case was made to depend on the expansion of air, was placed within the body of the stage, but under these conditions the temperature was found to vary within slight limits, according to the varying pressure of the gas supply, just as an air thermometer varies with the barometric pressure; there is, besides, a disadvantage in having the regulator at a distance from the source of heat. By employing the expansion of mercury to cut off all the superfluous gas, and by placing the regulator directly over the flame, the utmost constancy and delicacy are attained.

It is much to be regretted that, although we can learn the exact temperature of the chamber, we have at present no means of ascertaining how much that of the object under examination may differ from this; nevertheless, it is certain that the proximity of the objective of the microscope produces a considerable amount of cooling. If it be desired to reduce this by warming the objective, it is not difficult to introduce by means of glass T-tubes a secondary circuit of india rubber, the middle of which shall coil around the objective, whilst the ends shall be connected, the one with the ascending or inflow tube of the primary circuit, the other with the descending or outflow tube.

The reader will have noticed that the method by which the circulation is maintained in the apparatus here described is precisely the same as that employed in the hot-water apparatus now so extensively used for warming houses and conservatories; moreover, the principle of gas regulation is familiar to every laboratory student, and the screw regulator below is a modification of a contrivance used in some forms of barometer for altering the level of the mercury. Nothing, therefore, is claimed on the score of novelty, at the same time it is hoped that this adaptation of ordinary means to microscopical ends may prove of some service to the histologist.

[1] The author regrets that the figures have been executed on too small a scale. The following are some of the actual measurements (in inches and fractions of an inch) of the different parts of the apparatus:

Stage.—$3\frac{3}{4} \times 1\frac{1}{2} \times \frac{9}{16}$ inch; diameter of central chamber of stage $\frac{3}{4}$ inch; diameter of inlet and outlet tubes $\frac{7}{16}$ inch; diameter of tube for thermometer $\frac{1}{4}$ inch.

Reservoir.—Height 2 inches; outside diameter $1\frac{5}{8}$ inch; diameter of cavity for gas-regulator 1 inch; stand for reservoir (containing pin-hole gas burner) about $2\frac{1}{2}$ inches high. The stand may be of the same diameter as the reservoir, but, for the sake of stability, should have a broad, heavy foot.

Gas-regulator.—Bulb $1\frac{3}{4} \times \frac{7}{8}$ inch; lumen of tube about $\frac{1}{10}$ inch; length of tube 3 or 4 inches; thickness of side-screw about $\frac{1}{5}$ inch.

NOTES AND MEMORANDA.

On the Smallpox of Sheep.—Klein ('Proc. Roy. Soc.,' 1874, No. 153) describes the development of the primary pock at the point of inoculation in this disease, which closely resembles human smallpox; the fresh lymph used for inoculation contains very minute spheroidal micrococci and other forms not previously described, but closely related to micrococci. He notes three stages in its development—1. A progressive thickening of the integument over a rapidly increasing but well-defined area. 2. The formation of vesicular cavities containing clear liquid in the rete Malpighii; and 3, the filling of these cavities with pus-corpuscles and other structures. About the third day after the pock has appeared, there appear in the granular material, which now distends the lymphatics, spheroidal or ovoid micrococci, and branched filaments, either sparse or closely fitted together. This vegetation, after one or two days, presents the character of a mycelium, from which moniliform terminal filaments spring, each of which breaks off at its free end into conidia. The vesicles coalesce into irregular sinuses, and contain similar masses of vegetation, the filaments of which, however, are of such extreme tenuity, and the conidia so small and numerous, that the whole possesses the characters of zooglœa rather than of mycelium. The rete Malpighii becomes filled with migratory cells which originate in the corium; these soon find their way to the cavities formed by the coalesced vesicles, which are thus converted into microscopical collections of pus-corpuscles.

The Peach-coloured Bacterium ('Quart. Journ. Micr. Sc.,' 1873, p. 408).—Professor Ferdinand Cohn, of Breslau, writes, under date August 8th, to Mr. Ray Lankester:

"Your *Bacterium rubescens* is the same thing which Ehrenberg described (but did not figure) in his great work under the name *Monas Okeni*. The zooglœa-like form was called by Kützing *Protococcus roseo-persicinus*, but was published by myself last year in Rabenhorst's collections 'Cen-

turien der Susswasser Algen Europas,' under the name of *Clathrocystis roseo-persicina*, the adult form belonging to the genus *Clathrocystis* of Henfrey. I took much pains with the study of these curious organisms last year, before I was acquainted with your memoir on *Bacterium rubescens*, and I had in view to publish my researches in the next part of my 'Beiträge zur Biologie,' but the number has been delayed up to this moment.

"I must confess that, though I had strong suspicion of a genetic connection between *Monas Okeni* and *Clathrocystis roseo-persicina*, both being commonly found together, yet I could never find any convincing proof of it.

"I shall put the growth you favoured me with into the conditions described in your letter, and I hope to find, after my return from my summer's holiday, the development of the organism."

Mr. Lankester has observed further very interesting phases in the-life history of this alga, which will be described in an early number of the Journal. The most remarkable are large subspherical bodies, reaching as much as 200th inch in diameter. These are entirely homogeneous in structure, and deeply stained with Bacterio-purpurin. They appeared in the winter months, when the growth died down to a very small size. Finely granular bodies and somewhat more coarsely granular bodies of the same character were also found, leading by an easy transition to the spherical agglomerations of homogeneous oval plastids (zooglœa-like aggregations) figured in the Journal, October, 1873, from which it appears probable that the large structureless bodies develop by a multicentral segregation into the loosely connected aggregations of Bacterium-like plastids.

The Mode of Occurrence of Chlorophyll in Spongilla.—Mr. H. C. Sorby is at present engaged in an examination of the green colouring matter of *Spongilla* with the spectroscope. In 1869 I made some observations of the kind (published in the 'Journal of Anatomy and Physiology'), and showed by spectroscopical evidence that *chlorophylloid* colouring matter was present in this organism. Mr. Sorby informs me that he has recognised in *Spongilla* all six of the chlorophyll-constituents which he has distinguished in the higher plants (see his paper on "Vegetable Chromatology," 'Proc. Royal Society,' 1873). I have recently examined the morphological character of the chlorophyll of *Spongilla*. I find that among the amœbiform sponge-particles of a green-coloured specimen of *Spongilla*, some are composed of naked, finely molecular, colourless protoplasm, throwing out abso-

lutely hyaline lobose pseudopodia. The outline of the nucleus is not strongly marked, but the nucleolus is obvious enough. In others you may find one or two, three or four, or a crowd of twenty green-coloured granules. These granules have a uniform size, and a peculiar form, being concavo-convex discs or cups.

Spongilla, as is well known, is frequently colourless, or rather of a pale salmon colour. Hence it might be suggested that the green granules (the chlorophyll-bearers) are parasitic, as it has been suggested that the starch-bearing yellow cells of Radiolaria are parasitic. However, in the colourless *Spongilla* sponge-cells are found which contain *colourless* granules, corresponding to the green-coloured granules of the green sponge-particles. These colourless granules are, however, less definitely disc-like in form than the green ones, and are often irregular and angular.

It has been found that in the orchid *Neottia*, where chlorophyll is absent, a green colour may be developed by the action of strong sulphuric acid.

I have found that precisely the same thing is true of the colourless specimens of *Spongilla fluviatilis*. When immersed in strong sulphuric acid they gradually develop a strong leaf-green colour, fully as intense as that of the naturally green specimens. Microscopic examination after or during this treatment is not very satisfactory, but the colourless granules appear to be the parts which first turn green, though after the reagent has acted the whole mass of coagulated sponge-sarcode is uniformly impregnated with a green colour.

I remember to have seen it stated somewhere, on chemical evidence, that *Spongilla* contains a starch-like body. I should be glad if any reader of the Journal can refer me to an authority for this statement.

The above observations tend to show that chlorophyll in *Spongilla*, as in the higher plants, is preceded by a distinct chlorophyll-evolving substance, which is colourless.—E. Ray Lankester, September 20th.

Scalariform Ducts in the Prothalli of Ferns.—I have lately detected scalariform vessels in the prothalli of ferns which are quite similar to those described by Dr. Farlow in *Pteris cretica*. I am uncertain, however, of the species to which the prothalli belong, as I pick them out of a fern case in which I grow a variety of species of different genera. The scalariform vessels make their appearance just below the notch and run out towards it. In some there is a linear thread of one or two strands, in others a cluster of vessels—

only one or two running forward. In the prothalli which produce the vessels neither antheridia nor archegonia were found; the root-hairs are produced on both sides, so that it is difficult to say which is the upper or under side. A very young leaf, formed as an asexual outgrowth in one instance, did not appear to contain any vessels, but a great many hairs proceeded from it, generally 3-celled, and such as commonly occur about the first leaves of the normally developed embryo. On many of the prothalli containing archegonia the leaf was produced before the root. On the prothalli with asexually produced embryos I found the leaf on one side of the prothallus and the root on the other, which is never the case with embryos normally produced. JAMES ABBOTT.

[It may be well to state how the bibliography of Dr. Farlow's interesting discovery stands at present. His first paper upon the subject was communicated to the American Academy, January 27th of this year, and printed in its 'Proceedings,' pp. 68—73. Only separate copies have at present reached this country, and it is, therefore, uncertain if the paper is actually published in America. An independent communication, without figures, from Dr. Farlow appeared in the 'Botanische Zeitung,' March 20th, p. 180. The paper published in this Journal was revised by the author, and all the figures for the plates were also redrawn by him. Figs. 1, 2, 3, 4, and 8 were different to any that had previously appeared.—EDS.]

New Work by Prof. Haeckel.—We have received an early copy of Prof. Haeckel's new work published by Engelmann, of Leipzig. It is entitled 'Anthropogenie: Entwickelungsgeschichte des Menschen,' and gives in a popular form the facts of the development of the human ovum and also the zoological facts which bear on the ancestry of man. The work is, in fact, an enlargement with much new matter of the final chapters of the 'History of Creation' of the same author, now in its fourth edition. The embryologist will find in this work—although addressed to the "laity"—many important and highly suggestive views as to such questions as the homology of the germ-layers, the genital glands, and the primordial kidney.

QUARTERLY CHRONICLE OF MICROSCOPICAL SCIENCE.

HISTOLOGY.[1]

I. Technical Methods.—1. *A new Hot-stage.*—Panum ('Nord. Medic. Arkiv.,' viii) finds that in the hot-stages for microscopical observation now in use it is impossible to determine with accuracy the temperature of the object under observation, and there is the further inconvenience of condensation of water on the object. To remedy these defects he has constructed a hot chamber of tin plate, which surrounds the lower part of the microscope as well as the stage, light being admitted to the mirror through a movable pane of glass in front. The sides and back of the chamber are double, and thus form a large vessel containing water, which can be easily heated. The roof is perforated to allow the tube of the microscope to pass through, and also to admit a small thermometer, the bulb of which is placed near the object-glass. The object is introduced or manipulated through openings in the sides of the chamber, which can be closed with corks. The circulation of water enclosed in the walls of the chamber maintains a very uniform temperature; so large is the mass of heated material that the existence of small openings has little effect on the temperature of the air inside, nor is this materially affected even by opening the side or front windows.

2. *On the use of Chloral Hydrate in Histology.*—André (' Journ. de l'Anat. et de la Physiol.,' Jan., 1874) recommends the use of this reagent for the study of the retina. With a solution of 4 grms. chloral in 30 grms. water (sometimes with the addition of 16 grms. glycerine), the fibres of

[1] The articles in this division are arranged under the following heads:—I. Text-books and Technical Methods. II. The Cell in General. III. Blood. IV. Epithelium. V. The Connective Tissues. VI. Muscle. VII. Nervous System. VIII. Organs of Sense. IX. Vascular System. X. Digestive and Respiratory Organs and Glands. XI. Skin and Hair. XII. Urinary and Sexual Apparatus.

The Editors will be glad to receive, for the purpose of making this record more complete, copies of separate memoirs or reprints from periodicals, which must otherwise often escape notice. We have to acknowledge the assistance of Dr. Cavafy in making these abstracts.

Müller may be easily studied, and it is then evident that they represent axis-cylinders, as Müller supposed.

3. *On Freezing applied to Histology.*—Axel Key and Retzius ('Nord. Med. Arkiv.,' 1874, No. 7) find that if fine sections of frozen tissues be hardened before thawing, so that the tissues remain in the state they have assumed by freezing, they are generally pierced by a number of holes, fissures, and canals. Thus, in tendon there are longitudinal canals; in the skin, fissures and holes; in brain, spinal cord and liver, numbers of lacunæ and wide spaces traversed by trabeculæ. Precisely similar appearances are presented by sections of frozen blood, gelatine, and starchy matters. On following the process of congelation under the microscope they found that, at the moment of freezing, the water, in separating from the organic matter (brain, blood, or starch), forms branched acicular columns of ice which spread in various directions. If the mass be now hardened by alcohol or osmic acid, the spaces occupied by the ice remain as canals and cavities. If it be thawed, the mass becomes confused as it softens, so that the canals may be easily mistaken for normal structures. It follows that conclusions must only be drawn with the greatest caution from frozen objects, and never without verification by other methods. Still, freezing has a real value in certain cases, *e. g.* for transverse sections of delicate membranes, and some other objects in the fresh state.

II. The Cell in General.—*Development and Proliferation of Epithelia and Endothelia.*—Zielonko has studied, under Recklinghausen's direction, the growth of the cornea and other tissues detached from their normal situation. We must defer a notice of this important paper ('Archiv f. Mikr. Anat.,' x, 351).

III. Blood.—1. *On the value of High Powers in the Diagnosis of Blood-stains.*—Dr. Joseph Richardson ('American Journ. Med. Sci.,' July, 1874) advocates the measurement of the corpuscles from suspected stains by means of a micrometer eye-piece and high powers (1-50th or 1-25th immersion lens). He finds that by this means it is easy to distinguish with certainty stains produced by human blood from those of sheep's or ox blood. The method was successfully applied by Dr. Richardson in the following cases:—Prof. Reese and Dr. Weir Mitchell furnished him each with three packages of dried blood from stains made by sprinkling the fresh fluid from an ox, a man, and a sheep, upon white paper; the two series were simply numbered 1, 2, and 3, and each gentleman preserved a memorandum of the kind of blood composing each sample. Dr. Richardson then proceeded as follows:—Small

particles of No. 1 of Prof. Reese's set were broken up with a sharp knife upon a slide and covered with a thin glass. The minute masses of dried clot thus obtained were then irrigated by $\frac{3}{4}$ per cent. salt solution until nearly decolorised; a drop of aniline solution was then allowed to flow in beneath the cover, and in half a minute washed away and replaced by salt solution. The object was then examined with 1-25th immersion lens, and numerous coloured and colourless corpuscles were easily found. Ten measurements of coloured corpuscles gave a maximum of 1-3125th of an inch, a minimum of 1-3572nd, and a mean of 1-3407th. Specimen No. 2, similarly treated, gave a maximum of 1-4444th, a minimum of 1-4878th, and a mean of 1-4694th; and No. 3 gave a maximum of 1-5405th, a minimum of 1-6666th, and a mean of 1-5828th. Dr. Richardson concluded that No. 1 was human, No. 2 ox, and No. 3 sheep's blood, and was "entirely correct." The second series was similarly examined, and yielded the following results:—No. 1 gave a maximum of 1-4347th, a minimum of 1-4878th, and a mean of 1-4662nd; No. 2, a maximum of 1-5405th, a minimum of 1-6450th, and a mean of 1-5952nd; while No. 3 gave a maximum of 1-3175th, a minimum of 1-3572nd, and a mean of 1-3430th. Dr. Richardson here again rightly decided that No. 1 was ox, No. 2 sheep's, and No. 3 human blood. In no instance do the minimum diameters of human blood-corpuscles closely approach the maximum even of those of the ox. Dr. Richardson recommends that in examining spots of blood more than 1-10th of an inch in diameter fragments should be scraped from the edges or thinnest part of the stain, because the central portions show numerous fibrin filaments which form a meshwork more or less obscuring the corpuscles. He found that a specimen of dried human blood five years old still showed multitudes of corpuscles, which could easily be distinguished from those of the ox or sheep in the above manner, a mean of ten measurements giving 1-3425th inch. Dr. Richardson has thus proved, in opposition to the statements of writers on medical jurisprudence, that human blood-stains can be positively distinguished by the microscope even five years from the date of their production from those caused by *some* other animal's blood.

2. *Numeration of Red Corpuscles in the Blood.* By Dr. Malassez, Paris (Abstract in 'London Medical Record,' 1874, p. 132).

IV. Epithelium.—1. *On the Epithelial Arrangement in Front of the Retina and on the External Surface of the Capsule of the Lens.*—Ewart ('Journ. of Anat. and Physiol.,' May, 1874, p. 353) examined these parts in the eyes of various animals

by the silver process. He found the membrana limitans interna to consist of (or to have immediately in front of it) a mosaic of epithelial cells. These, in the ox, are multiform, fit closely into each other, forming a continuous layer over the whole retina. The small spaces between the larger cells are occupied by hexagonal small ones, forming a centre from which the larger cells radiate. The margins of the cells are irregular, but not serrated, and there are round or crescentic nuclei well brought out by hæmatoxylin and acetic acid. Ewart also describes the lymphatic sheaths of His, as enveloping all the vessels of the retina, and not only the small and medium sized ones. The above-described epithelial layer could not be traced beyond the ora serrata. The posterior surface of the capsule of the lens is also covered by a layer of epithelium, which in the ox consists of large polygonal cells with a distinct nucleus and irregular margins, processes from one cell dovetailing into those in immediate contact with it.

2. *Epithelium of the Bile-Ducts.*—Ch. Legros, "Sur la structure et l'épithelium propre des canaux sécréteurs de la bile" ('Journal de l'Anatomie,' 1874, p. 137; 'Centralblatt,' 1874, p. 581).

V. Connective Tissues and Lymphatic System.—1. *On the Subarachnoid Trabeculæ.*—Axel Key and Retzius ('Nord. Med. Arkiv.,' No. 7, 1874) describe these as consisting of fibrillar connective tissue entwined by elastic fibres, and covered by a cellular sheath. At the base of the brain and cerebellum there are trabeculæ completely enclosed in a delicate fibrillated sheath, whose fibres run circularly for the most part, but sometimes obliquely, forming spirals. There are also longitudinal fibres in the sheath, and sometimes it is composed of alternate layers of longitudinal and circular fibres with intercalated nuclei. One fibrillar sheath may enclose several connective-tisue bundles. Acetic acid does not cause the fibres of the sheaths to swell up, but, again, they are not rendered more distinct, as is the case with elastic fibres. On the contrary, they become paler and less clear. These trabeculæ are also covered by a single layer of easily detached flattened cells.

2. *Contributions to the Histology of Connective Tissue.*—Löwe ('Centralblatt,' 1874, p. 145) makes the following statements:—Every serous membrane has two layers. The superficial layer is formed of endothelial plates. The deeper layer consists of a homogeneous matrix, containing flattened, square, distinctly nucleated cells, arranged in regular rows. If elastic fibres are present they are situated between the two layers. The same structure can be shown (1) on the

delicate membranes which everywhere cover trabeculæ of connective tissue (endothelial membranes); (2) on the sarcolemma; (3) very easily on the delicate membranes surrounding primitive bundles of tendon. Thus, around each muscular fibre and each primitive tendinous bundle a serous cavity can be shown to exist, as has been done for nerves by Axel Key and Retzius. Löwe concludes that all fibrillar connective tissue is composed of membranes of the nature of serous membranes, and that consequently every cavity in the tissue must be viewed as a serous cavity.

2. *On the Medulla of Bone.*—Robin ('Journ. de l'Anat. et de la Physiol.,' Jan., 1874) has a long memoir on medullary cells, of which, according to him, two coexistent varieties may be found, the first being a complete cell, the second a free nucleus, similar to the nuclei of the preceding cells. These elements are always most numerous in those parts in which there are few fat-cells (fœtal medulla, red medulla). The size of the complete medullary cells is about that of leucocytes, but their reactions with water and acetic acid are quite different. Water does not make them paler, and only causes them to swell very slightly. The granular appearance is not modified, and no Brownian movement of the granules is produced; their nuclei are not affected by acetic acid. Robin does not agree with Hoyer, that the capillaries, arterioles, and venules of medulla are destitute of walls, nor does he admit the opinions of Bizzozero, Monat, and Neumann, who consider the medulla as an organ for the formation or destruction of coloured blood-corpuscles. The first of these opinions is based essentially on an identity between the medullary cells and leucocytes, and this, according to the reactions above given, is denied by Robin.

4. *On the Endothelium of Serous Membranes.*—Tourneux studied these ('Journ. de l'Anat. et de la Physiol.,' Jan., 1874) on newts, frogs, and toads, by the silver process. New results, or rather new interpretations, are given as to the relation between the peritoneal endothelium and that of the cisterna lymphatica magna. The pits or depressions seen at the points from which the peritoneal endothelial cells radiate, and which have been considered as natural perforations (stomata) in the wall of the lymphatic sac, by which it communicates with the peritoneum, are, according to him, crateriform depressions of the peritoneum, which are occupied by one or two delicate protoplasmic masses, representing endothelial cells in their first stage of development. If these young cells are partly or entirely destroyed in the preparation of the object, true perforations of the wall of the cisterna

result, but these are only accidental. In many cases these young cells only form the entire thickness of the cisterno-peritoneal wall at these points. Finally, an examination of the contents of the cisterna, and some experiments on inflammation of the peritoneum, tend to confirm the author in his belief that these cavities do not communicate.

5. *On the inner Boundary Layer of Human Serous Membranes.*—Bizzozero ('Centralblatt,' 1874, No. 14) examined the pleura, pericardium, and peritoneum, and in each case found an extremely thin connective-tissue layer immediately under the endothelium, which can often be more or less easily detached as a delicate membrane. This is most easily effected on the intestinal peritoneum and parietal pleura, both in fresh preparations and in those which have had their endothelium removed by pencilling, and then been hardened in dilute spirit, potassium bichromate, or very dilute chromic acid (0·01 per cent.). The isolated membrane is one to two inches thick, homogeneous, finely granular, or fibrillar, contains no cells, and swells up and becomes pale by acetic acid. Its inner surface is covered by the endothelium, while its outer surface rests on the wavy, felted connective-tissue bundles of the serous membrane, in which there are numerous cells. In the intestinal peritoneum it is separated by a few thin connective-tissue bundles from the already known reticulated elastic membrane. Both here and in the parietal pleura this membrane forms an *uninterrupted* layer. According to the above it appears that, at least in the human pleura, there can be no direct opening of lymphatic vessels into the pleural cavity as described by Dybkowsky, E. Wagner, Klein, and others. This structureless layer apparently corresponds to the basement membrane described by Todd and Bowman, and denied or ignored by later writers.

6. *On the Lymphatic System of the Cornea.*—Dr. Thin ('Lancet,' 1874, p. 225), by means of impregnation with silver and gold, shows that the tubes described by Bowman in the cornea are lined by a layer of endothelium, which he considers to be of a lymphatic nature. The endothelium may be easily seen in old preparations, but may also be made out in recent ones, and shows the existence of lymphatic vessels in the cornea. His drawings of preparations of the rabbit's cornea show large lymphatic vessels lined with a distinct endothelium, and smaller vessels joining to form a trunk. There are also clear spaces corresponding to the lymph-canalicular system, in which the corneal corpuscles are lodged. These canaliculi all communicate with each other and with the lymphatics. In preparations in which

the silver nitrate has penetrated more deeply, one may even see that the endothelial layer extends to the canalicular system, and is continuous with the endothelium of the tubes. Hoyer and Schweigger-Seidel have noticed the dark lines seen in silver preparations of the cornea, but have not considered them to show the presence of an endothelium. Rollett thinks that these lines can only be seen in the corneæ of young animals, whose fibrillar substance is in course of development, but Dr. Thin has observed them in the adult also. Further, by using both silver nitrate and gold chloride he has seen that the nerves coloured by the latter reagent are contained in the cavity of the lymphatic, which they fill almost completely; but a narrow, clear space can be distinctly seen between the nerve and the wall of the lymphatic. The branches of the nerves given off from the chief trunk have a similar relation to the smaller lymphatic vessels in which they are contained.

7. *On the Structure of Lymphatic Glands.*—Bizzozero (separately printed memoir) has investigated the reticulum of the lymph-paths in the dog, man, rabbit, and calf. This is commonly described as consisting of homogeneous or delicately striated fibres, with here and there a nucleus, or in some places as composed of stellate connective-tissue-corpuscles, communicating with each other and with the fibres by numerous processes. Billroth ('Virchow's Archiv,' vol. xxi, p. 347) had already stated that in chronically inflamed glands the nuclei had partly developed into spindle cells, which were merely applied laterally to the fibres. This, however, appears to be the normal condition, according to Bizzozero. In fine sections of hardened glands of the dog, which have been freed from lymph-cells by shaking in water, the cellular elements of the reticulum can be recognised as spindle-shaped, stellate, or flattened cells, with a coarsely granular protoplasm, often containing fat- and pigment-granules. The nucleus is oval, finely granular, and contains one or two shining round nucleoli. Their number varies with the time for which the preparations are shaken. At first there are large numbers of them, even in adult animals, but the longer the sections are shaken the more is the reticulum freed from them, so that in good preparations they may all be dislodged without injury to the adenoid network. This fact is enough to prove that the cells are simply applied to the fibres—that they are contiguous to but not continuous with them. This can also be seen with high powers in sections in which the cells are still present. The cell may then be seen either to surround a fibre, which then becomes

enclosed in a tube of protoplasm, the nucleus being closely applied to the side of the fibre; or it may be thin and flattened and spread out in one of the meshes of the reticulum, which it occupies as a picture does its frame; the nucleus then occupies the centre of the mesh. A similar arrangement holds good in the other animals examined.

Bizzozero affirms that in the reticulum of the follicular cylinders the same relations may be seen. The reticulum here consists of delicate, homogeneous, communicating fibres, flattened and broad at the nodular points. It is on, and not in, these nodular points that the cells lie. They consist of an oval nucleus with a very narrow protoplasmic zone, and can also be dislodged by prolonged shaking, without injury to the reticulum.

Bizzozero has also succeeded in demonstrating the existence of a layer of endothelium covering the follicular cylinders, and thus forming the wall of the lymph-paths.

8. *Normal and Pathological Anatomy of the Lymphatic System of the Lungs.*—Klein ('Proc. Roy. Soc.,' 1874, No. 149) gives a full description of the above, as seen in guinea-pigs, dogs, cats, rats, and rabbits. The endothelium of the surface of the pulmonary pleura consists of a single layer of polyhedral cells, which are not flattened, but shortly columnar and granular, that of the costal pleura being formed of much flattened, almost hyaline plates. The pulmonary pleura consists of a thin layer of connective tissue, with a very rich network of elastic fibres, the matrix usually contains one layer of flattened connective-tissue-corpuscles. Beneath the pleura, in the guinea-pig, there is a membrane consisting of unstriped muscle, arranged in bundles so as to form a mesh-work, with elongated large meshes, which have a greater diameter in the distended than in the collapsed lung. These muscular bundles radiate from the apex to the base of the lung, and are most abundant on the anterior external and internal surfaces; on the posterior surface they are scanty, and become more and more so near the spinal column, the fibres being most richly distributed over those parts of the lung which move most actively in respiration. In rats, rabbits, cats, and dogs, the muscular bundles occur more sparingly.

Pleural Lymphatics.—The meshes of the muscular membrane in the guinea-pig's lung are lined by a single layer of flattened endothelium, and constitute a communicating system of lymphatic sinuses, which communicate freely by true stomata with the pleural cavity. The cells of the membrana propria of the pulmonary pleura (lymph-canalicular system)

send forth processes which project between the endothelium of the free surface, forming pseudostomata.

Sub-pleural Lymphatics.—The pleural lymphatic sinuses communicate with lymphatic tubes lying in grooves corresponding to the most superficial groups of the alveoli of the lung. These vessels have valves, and anastomose to form a network, which receives branches originating between the alveoli of the superficial portions of the lung. These inter-alveolar lymphatics commence in the lymph-canalicular system of the alveolar septa, whose cells are in direct continuity with the endothelium of the lymphatics.

Perivascular Lymphatics.—These originate also from branched cells in the alveolar septa, the capillaries being collected into trunks which accompany the branches of the pulmonary artery and veins. They either run in the adventitia of these vessels in twos or threes, anastomosing with each other, or the blood-vessel is entirely or partially invaginated in a lymphatic. The branched cells of the alveolar septa, from which the capillaries of this system originate, send processes between the epithelium into the cavities of the alveoli, thus forming pseudostomata. This is the only means of communication between the alveolar cavities and the lymphatics.

Peribronchial Lymphatics.—These vessels are usually distributed in the adventitia of the bronchi, anastomosing with each other and with the perivascular lymphatics. Their capillaries originate in the mucous membrane of the bronchi and pierce the muscular coat. The wall of these capillary branches is continuous with the branched cells of the mucosa, which also penetrate, as a nucleated reticulum, between the epithelium of the bronchus and project on its free surface, forming pseudostomata. The lymphatics are always most numerous on that side of a bronchus which is turned towards a branch of the pulmonary artery. In the course of the smaller bronchi, whose walls have no cartilage, there are generally several vascular lymphatic follicles, which are surrounded by a lymphatic vessel, as the lymph-follicles of Peyer's patches are by their lymph-sinuses. These follicles extend to the muscular coat, and in some cases may be traced through it to the mucosa. These follicles always lie in the wall of a lymphatic vessel, between the bronchus and the accompanying branch of the pulmonary artery. They are of different sizes, and generally spherical or elliptical. These peri-lymphangial follicles are especially numerous in the guinea-pig's lungs, and are constantly growing and being reproduced. The lymphatic vessels of the two last-mentioned

systems anastomose with each other in the ligaments of the lung, and finally enter the bronchial lymphatic glands.

The second portion of Klein's paper is occupied by a description of the pathological changes which occur in artificial tuberculosis in animals, of which we can only give a very short account. The first structural changes which appear in the guinea-pig's lung consist in the appearance of perivascular lymphatic nodules and cords. These commence in the ultimate branches of the pulmonary artery, whose endothelium germinates until the lumen of the vessels is nearly blocked by its products; the lymphatics become converted into adenoid tissue, which grows from the endothelium both internally (endolymphangial) and externally (perilymphangial). These perivascular lymphatic (tubercular) cords spread both along the lymphatics to the larger branches and also towards the interalveolar branched cells. The capillaries of the affected alveoli then become converted into solid nucleated bands and threads, which are continuous with the surrounding reticulum. Secondary to the above process, there is a thickening of the alveolar septa, and a proliferation of the epithelium filling the alveoli, often intermixed with lymphoid corpuscles. Sometimes the enlarged epithelial cells become fused into one multinuclear "giant-cell." When this is the case the giant-cells gradually become changed into a fibrillated tissue with few cells, which rapidly spreads, and finally undergoes first a fibrous, then a cheesy degeneration. The adenoid tissue of the perivascular cords never degenerates. The secondary process passes from the infundibula to the bronchi, whose epithelium proliferates abundantly, while the branched cells of the mucosa become converted into adenoid tissue. The process above described takes place in man in inverted order, *i. e.* the first changes are seen in the alveoli and interalveolar septa, and these changes are followed by the appearance of perivascular cords.

9. *Lymphatics of the Thyroid.*—J. Nawalichin (of Kasan) in 'Pflüger's Archiv,' vol. iii; abstract in 'London Medical Record,' 1874, p. 262.

10. *On the Cartilages and Synovial Membranes of the Joints.*—Reÿher ('Journ. of Anat. and Physiol.,' May, 1874, p. 261) investigated the formation and development of the so-called "marginal zone" of the synovial membrane, *i. e.* the portion which extends over those parts of the articular surfaces which are not ordinarily in contact, the question being whether this is an ingrowth from the synovial membrane or not. For this purpose the joints of embryos and

young animals were examined, and compared with those of adults and with human joints at different ages. These were treated by silver, hæmatoxylin, and gold, and studied on surface sections. On examining the head of the femur of a sheep's embryo one and three quarters inch long, the layer of cells described as an epithelium by Todd and Bowman and Reichert was found not to exist; there is only a homogeneous substance with nuclei embedded, surrounded by a variable amount of protoplasm. Precisely the same appearances are shown by the deeper parts of the cartilage. In more advanced embryos (sheep, two and a half inches long) other places are also found in which the nuclei are rather more separated, brown lines appearing here and there between them. Later on, the brown lines become more frequent and broader, and in some places form a network like that on the surface of serous membranes, but with smaller and more irregular territories. In other embryoes the greater part of the articular surfaces is covered with these flat epithelioid cells. This appearance is due to the gradual development of intercellular substance, which increases, the cells becoming separated by broad bands of matrix, and at the same time becoming irregularly angular, stellate, or elongated, with long processes which dip down obliquely into the matrix. The matrix grows over as well as between the cells, so that in the adult there is a distinct hyaline layer covering the surface of the cartilage. While this is occurring the irregular, stellate, angular, and elongated cells become gradually transformed in parts where the articular surfaces are constantly in contact, with loss of their processes, into the round scattered cells of ordinary cartilage.

At the time when the articular surface proper has the above epithelioid appearance, the same can be traced over its margin as far as the insertion of the capsule, where, in the adult, vessels and irregularly disposed cells are to be found. The cells are of the same size as those covering the cartilage, but less polygonal, and separated by more intercellular substance, into which they send short knobbed processes, not long and tapering ones, as in the adult. There is every transitional form between these and the cartilage cells, which, as they approach the synovial membrane, begin to exhibit a gradually increasing number of processes, and become more irregular, until they precisely resemble those on the inner layer of the capsule, with which they are connected by freely communicating branches. As development proceeds these appearances are reversed, the cells being widely separated and of irregular forms over the cartilage, whilst near and

upon the capsule they are epithelioid. These cells, whether possessing processes, or arranged like an epithelium, must be looked upon as connective-tissue corpuscles. In the synovial membrane itself Reÿher also denies the existence of an epithelium. Places may be found on the inner surface of the capsule with the cells regularly arranged, but these patches are never extensive. The irregular branched form of cells persists throughout life on the inner surface of the capsule; but on the surface of the cartilage a change occurs, depending on the growth of the articular surfaces and on the varying conditions of contact and pressure to which they are exposed. On concave articular surfaces, whose growth is more or less uniform both near the centre and at the periphery, the cells, whether epithelioid, stellate, or rounded, are more or less similar throughout; whereas on convex surfaces, such as the head of the humerus or femur, the superficial cells near the neck are far less separated than those nearer the centre of the articular surface, when growth and development are more rapid. Again, in parts of the surface which are always in contact, the epithelioid cells become as development proceeds irregularly stellate, finally losing their processes and becoming round, so that at birth the epithelioid arrangement has mostly disappeared. The converse had been already shown by Reÿher by keeping the joints of dogs at rest, so as to remove all effects of pressure and movement. The cells on the articular surfaces then again take on a more or less epithelioid arrangement, accompanied by an absorption of intercellular substance, and this extends also to the deeper layers of the cartilage. Hence the synovial process is not to be looked upon as an ingrowth of the synovial membrane as, some have asserted, but rather as being formed *in sitû* as the development of the joint proceeds, its cells being intimately related both by the history of their development and by the presence of intermediate forms with the cartilage cells of the articular surface.

11. *Development of Bone.*—Ranvier ('Quelques faits relatifs au Developpement du Tissu Osseux,' 'Comptes Rendus,' 1873, ii, lxxvii, 1105; 'Centrablatt,' 1874, p. 452).

12. *Connective Tissue of the Spinal Cord.*—Ranvier ('Comptes Rendus,' 1873, ii, lxxvii, 1299; Centralblatt,' 1874, p. 483) contends that this is similar to the connective tissue of the peripheral nerves.

13. *Bone-Absorption by Means of Giant-Cells.*—Mr. Alexander Morison ('Edinburgh Medical Journal' for October, 1873), taking up the researches of Kölliker on absorption of bone by means of giant-cells (see 'London Medical Record,'

1873), finds, on examination of sections through the jaw prior to the formation of the tooth-sac, that many giant-cells contain clear round or oval holes of various sizes. The larger and more distinctly defined ones, in the centre of which a débris resembling fatty particles is sometimes to be detected, appear to be originated by a disintegration of minute portions of the protoplasm of the giant-cell. From this the author takes it as possible that the giant-cells, after having ceased to exercise their destructive, *i. e.* absorbing function, become disintegrated. Morison takes it also as probable that sequestra are separated from living bone by means of giant-cells, for, on examining a fresh sequestrum from a case of necrosis of the tibia, there were found Howship's lacunæ covering all aspects of the sequestrum, and the blood and pus around the preparation contained multinuclear giant-cells floating about.

As regards the origin of giant-cells, Morison agrees with Kölliker and others that many of them are in genetical connection with the osteoblasts, but that others probably develop from embryonic connective tissue; for there occur bone-spaces with here and there a giant-cell entirely destitute of osteoblasts, but containing the nuclei of embryonic connective tissue. These nuclei, generally scattered, are here and there closely aggregated and show an internuclear opacity, which, however, has not the distinctly granular appearance of the opaque cell-substance of a fully developed giant-cell; but this appearance is in variable degree, even in fully formed cells. It is possible that the aggregation of nuclei may be the first stage in the formation of a giant-cell; one has only to imagine that these nuclei prepare a cell-material each around itself, which, coalescing with that round its neighbours, produces the multinuclear giant-cell.—E. Klein, M.D., *in 'London Medical Record.'*

14. *On the Absorption of Bone.* Rustizky ('Virchow's Archiv.,' lix., p. 202) confirms the presence of giant-cells in normal and pathological absorption of bone. He finds that there are three modes in which they occur, either only in a single layer immediately on the surface of the affected portion of bone, or also in the periosteum; or lastly, also, in the interior of the bone. The presence of giant-cells could not be shown in all cases of bone-absorption, and notably not in the little depressions formed on the inner surface of the calvaria by the Pacchionian bodies, nor in a sternum which was partially atrophied by the pressure of a hypertrophied heart. Hence the author does not accept Kölliker and Wegener's views, that long-continued pressure against a bone

is the chief cause of the formation of giant-cells; which are, moreover, found in large numbers on the external surface of masses of callus, where there is no appreciable pressure. Still it was possible to produce atrophy with giant-cells artificially in animals, by long-continued local pressure on a bone; but they were also found in the interior of the bone, where pressure could not of course operate directly. Further, the author found that giant-cells were developed in the lymph-sacs of frogs, after the irritation caused by the introduction of various foreign bodies, so that he considers their formation to be largely due to an alteration of nutrition, which is perhaps brought about by pressure. Amœboid movements were seen in some giant-cells, but not in others, especially in those whose protoplasm contained fatty granules. The author therefore draws a distinction between "fixed" and "migratory" giant-cells. In the latter, division was seen. The author concludes that giant-cells may be developed from any form of cell, and that their appearance in bone is not secondary to the formation of Howship's lacunæ.

VI. **Muscle.**—1. *Structure and Action of Striated Muscular Fibre.*—Dwight ('Proc. Boston Soc. Nat. Hist.,' vol. xvi, Nov., 1873) used the legs of *Gyrinus*, which are sufficiently transparent to permit the examination of their muscles *in sitû*. When at rest, but extended between its points of attachment, the fibre is straight-bordered, and shows a series of broad grey bands with a white border, separated by narrow black granular bands. When the fibre is free from all strain or resistance (as when one of its attachments is divided or moved much nearer to the other), the fibre is much broader, the black bands a little narrower and closer together. The white and grey stripes are also narrower, especially the former. The fibre has a scalloped border, the greatest bulging being opposite the middle of the grey. When the fibre is stretched it is narrower, with a more sharply defined outline. The black granular bands become separated into two parallel dotted lines, separated by a clear space. The grey bands become lighter and the white borders darker, so that the distinction between the two is less clearly marked. The state of active contraction is difficult to observe, owing to the incessant changes as the wave passes along the fibre. A part of the fibre is seen to dilate, the black bands become more prominent, approach each other, and seem to run with the wave along the fibre. The grey bands (the contractile element) disappear, so that there is only an alternation of black and white stripes, the borders of the fibre being very frequently, probably always, festooned or scalloped. The

grey band seems to disappear in an early stage of contraction, but this is not easy to make out. There seems to be no law regulating the wave of contraction, which may run towards or away from the tendon. Dwight has never seen the fibre assume a homogeneous appearance during contraction, as stated by Merkel, nor during repose, as Schäfer thinks. Longitudinal striation was only seen in unhealthy fibres. It is superficial, and probably only in the sarcolemma. Dwight concludes that "the fibre consists of a sheath, the sarcolemma, and of a ground substance, in which elements which may be provisionally called granules are embedded in transverse double rows. There is no reason to suppose that the difference between the white and the grey has any other than an optical cause, namely, that the part of the ground substance nearest the black bands receives, not only the rays of light that would naturally strike it, but others reflected or refracted, or both, from the black bands, and which do not strike the middle of the space between the latter (Heppner, Schäfer). If this be admitted, it is merely a corollary that in contraction the grey should disappear, as is the case. No appearances have been seen that are suggestive of the bundles of Schäfer's dumb-bell-like rods, which, indeed (judging from the abstract of his paper), he has assumed rather than demonstrated. As has been already stated, nothing like fibrillar structure is to be seen in the living and healthy fibre.

The sarcolemma is firmly attached to each edge of the ends of the black bands, and the granules must, in some way, be prevented from spreading laterally, so as to give support for the folds into which the muscle contracts. The ground substance is the contractile element; it is also highly elastic. When the fibre is stretched all parts become narrower, and when contracted broader, but in the latter case the change is chiefly in the ground substance.

2. *Some Points relating to the Histology and Physiology of Striped Muscles.*—Ranvier ('Arch. de Physiol.,' Jan., 1874) has examined the action and structure of the two kinds of striped muscles (excluding the heart) that are found in some animals. These are pale and dark red muscles. Thus, in the rabbit the semitendinosus, crureus, quadratus femoris, and soleus, are red; while the internal vastus, triceps femoris, adductor magnus, biceps, &c., are pale muscles. The same distinction is found in fishes, and in skates and torpedoes there are muscles formed of the two kinds of fibres. The dark colour of the red muscle does not depend on its containing more blood, as when all the blood has been washed out

by injection through the aorta the semitendinosus of the rabbit remains distinctly redder than the biceps (see Lankester on "Distribution of Hæmoglobin," 'Proc. Roy. Soc.,' 1873).

Physiologically, these two kinds of muscles differ from each other. When stimulated directly, the red muscles contract slowly and progressively, and on cessation of the stimulus again gradually relax. The contraction of the pale muscles, on the other hand, is brusque and sudden.

If the sciatic nerve be cut in two places, first, at its exit from the sciatic notch; second, in the middle of the thigh, and the isolated portion stimulated, a contraction of the semitendinosus (red) and of the neighbouring pale muscles takes place—the former slowly and gradually, the latter sharply and suddenly. On cessation of the stimulus the pale muscles relax suddenly, while the red muscle returns slowly to its former dimensions.

As these differences can be observed by direct stimulation in curarised rabbits, it is plain that they are inherent in the muscles themselves, and do not depend on the nervous system.

There are striking differences of structure in the two groups. The ultimate fibres of the red muscles show very abundant nuclei, disposed in longitudinal rows. In the pale muscles they are scattered and few in number. On transverse sections, made after drying and coloured by carmine, four to nine spherical nuclei can be distinguished in each fibre of the red muscles, occupying slight depressions in the muscle substance, or even embedded in its centre. The transverse section of a pale muscle-fibre shows no more than one to four flattened nuclei immediately beneath the sarcolemma. In skates and other fishes the muscle substance is separated from the sarcolemma by a granular layer. Flattened nuclei surrounded by a thin layer of protoplasm cover the deep surface of the sarcolemma, and others are embedded in the muscle substance. Those which occupy the deep surface of the sarcolemma are much more numerous in the red muscles.

Ranvier concludes by suggesting that the pale muscles with their sudden contraction may be the muscles of action, while the slowly and more persistently contracting red muscles may have a function of equilibration or regulation.

3. *Living Muscle.*—Wagener has made observations on living muscles in the transparent larvæ of *Corethra plumicornis,* which he specially recommends for this purpose ('Archiv f. Mikr. Anat.,' x, 293).

4. *Muscles in Typhus.*—In another memoir (Ibid, 311), Wagener studies the alterations of muscular tissues in typhus and typhoid fever.

[Heads VII—XII are unavoidably postponed.]

PROCEEDINGS OF SOCIETIES.

Medical Microscopical Society.

Friday, June 19th, 1874.

Osteo-sarcoma.—Mr. Needham read a paper upon this subject, taking as a foundation the case of a young man who entered one of the metropolitan hospitals with what appeared to be an osteo-sarcoma of the head of the tibia. Hard tumours, small in size, were felt in the groin, as well as deeply beneath the muscles of the thigh. The patient eventually died from chest complication, frequent hæmoptysis being a leading symptom.

At the post-mortem the growth on the leg was found, as diagnosed, to be an osteo-sarcoma, while similar growths were found in various parts of the body, and especially in the lungs. Microscopically the growth on the tibia—which was subperiosteal—had the characters of true osteo-sarcoma; but elsewhere only calcareous material was found, instead of bone with lacunæ, &c.

Specimens and drawings illustrative of the case were exhibited. The case will be published fully elsewhere.

Mr. Golding Bird objected to the term osteo-sarcoma, since calcareous deposit in lieu of bone was found, except in one place. He considered the earthy deposit as accidental rather than essential to the growth as indicating degeneration.

Dr. Pritchard did not consider calcification in all cases a degeneration; from its early appearance at times in morbid tissues he considered it as much a part of the growth in which it occurred as was true bone in an osteo-sarcoma.

Mr. Needham, in reply, agreed with Dr. Pritchard in not considering the calcification as degenerative, and was willing to confine the term osteo-sarcoma to the parts of the growth only where osseous tissue with lacunæ could be found.

Imbedding in Elder Pith.—Mr. Golding Bird read a paper on the method adopted abroad of cutting sections of tissues imbedded in elder pith, and packed in a microtome especially adapted for the purpose. The various steps in the operation were exhibited and explained at the same time. The principle on which the process depends is the expansion of the dried elder pith on the addition of water, so that if packed in the tube of the microtome in the dried state, and then allowed to imbibe moisture, anything previously imbedded in it is firmly gripped. The paper will appear *in extenso* in the 'Quarterly Journal of Microscopical Science."

In the discussion that followed,

Mr. Needham thought the pith would not give sufficient support on all sides of the tissue.

Mr. Groves approved of the combined use of pith and wax in the way that had been shown, as overcoming many difficulties in the use of wax for imbedding in a microtome, and as rendering the pith more efficient in some cases. He did not prefer a microtome that had to be held in the hand.

Mr. Giles thought the small size of the bore of the instrument might be at times objectionable. Suggested the use of dried carrot, if pith could not be obtained; it would swell and soften on the addition of water, like pith.

The Chairman objected to the pith-packing in the case of diseased spinal cord, though in a healthy specimen the pressure exerted might not be deleterious. On the whole, he thought the method described simple, quick, and one giving comparatively no trouble; while the microtome, being held in the hand, was for some reasons an advantage. He should certainly adopt the pith-process in future.

Mr. Golding Bird, in reply, stated that, if properly arranged, equal support could be given to the specimen on all sides by the pith, or even the combined use of wax with pith would overcome every difficulty on that point. He thought that carrot on swelling would be too hard to cut conveniently, or would exert too much pressure. The only reason for using a microtome with small bore was to save pith, and large specimens he did not as a rule imbed, but cut by hand. Had never used pith with diseased and therefore softened spinal cords, but for normal nerve-tissue had seen it used with the very best results; a proper degree of hardening in some fluid first was all that was required.

Friday, July 17th, 1874.

Skin Grafting.—Mr. Golding Bird read a paper on the mode of growth of the new epithelium after skin grafting, or at the edge of a skinning ulcer. Specimens illustrative of the subject were exhibited.

A summary of the changes observed is as follows:—A prolongation of the epithelium forming the rete mucosum of the adjoining skin, in a horizontal direction over the surface of the neighbouring granulation tissue; the vertically placed cells of the rete mucosum losing their upright position, and becoming more and more inclined till quite horizontal; the epithelial scales placed more superficially taking no part in the process, but becoming shed, so that the new epidermis was only one third the thickness of that of the skin from which it had sprung. He ascribed the adhesion of the new epidermis to the underlying granulation-tissue to the insertion of the former into the most superficial layer of the latter, the intercellular material of which may be seen becoming fibrillated like the

fibrin of blood-clot coincidentally with the growth onwards of the epithelium, the granulation-cells disappearing in great numbers at the same time. He had never yet been able to find the granulation-cells becoming developed into epithelium, but he had seen a few of them lying beeween the cells of the epidermis. The granulation-tissue beneath the earliest formed epithelium was the first to become developed into fibrous tissue.

Mr. Coupland thought the disappearance to the naked eye at times of a graft, and the subsequent growth of epidermis at the spot grafted some time after, was a proof of the development of epithelium from granulations.

Mr. Schäfer referred to the observed transformation of white blood-corpuscles on the recently blistered surface in the frog.

Mr. Golding Bird, in reply, denied that a graft that reappeared as stated had ever in reality disappeared. He believed that the deepest layer of epithelial cells was always left, though not visible to the naked eye.

Pacinian Corpuscles.—Mr. Schäfer gave an account of these bodies, discussing generally the various opinions held regarding them. He explained their several component parts, and held that the "core" was the layer of protoplasm described by Ranvier as covering the medullary sheath of the nerves. He had seen a nerve pass from one Pacinian body to another.

Dr. Pritchard asked if the Pacinian bodies in the cat's mesentery were the same as in the skin.

In reply Mr. Schäfer stated he considered them identical.

Mycetoma.—Microscopic specimens of the "Fungous Foot of India" were exhibited by the President.

Dublin Microscopical Club.

23rd April, 1874.

An Apparatus for Collecting Dust Particles.—Dr. J. Barker showed an apparatus he had devised and constructed, intended to obtain "dust samples" from the air, having modified for the purpose a "fan-bellows," to cause a draught inwards by means of the fanners through a wide lateral tube, within which were fixed a number of grooves to receive a few slips of glass moistened with glycerine. These were, of course, removable for examination for spores, &c., under the microscope. By bringing this apparatus into use upon heights, &c., samples of the particles carried by the atmosphere could be obtained.

Nucleus of Ovule of Welwitschia. — Dr. McNab exhibited a preparation of the apex of the naked nucleus of the ovule of *Welwitschia*, to which numerous pollen-grains with the pollen-tubes

were attached. He remarked that, whether we accept the carpellary theory or not, the pollen-grains of archisperms or gymnosperms are invariably applied to the naked nucleus of the ovule, and not to a stigma.

Microscopical Structure of Spine of Colobocentrotus atratus, Agassiz.—Mr. Mackintosh showed a transverse section of a spine of *Colobocentrotus atratus*, Agassiz, which forms a somewhat elongate ellipse, the major being about twice as long as the minor axis. When viewed under a low power the general appearance is Accrocladia-like, but differs in the irregular arrangement of its periodical rings, in the absence of the wide central reticulation, and in its oval form; the radiating solid lines, also, which are so strongly marked a feature in Accrocladia, are absent in *Colobocentrotus*. When examined under a higher power the central part is seen to be occupied by a regular network with very small interspaces, and bounded by a ring of solid pillars, outside which the reticulation becomes irregular, and continues so to the circumference, the largest spaces being situated at the extremities of the major axis. The external edge is crenulated, the prominences forming the longitudinal ribs which project on the surface.

Navicula Jamaicensis, Grev., *and a Form of Surirella fastuosa*, Grev., *from Philippine Islands.*—Rev. E. O'meara showed *Navicula Jamaicensis*. Greville; also the peculiar form of *Surirella fastuosa* described by Greville ('Quart. Journ. Micr. Sci.,' vol. x, Pl. III, fig. 1). These were found in material scraped from shells brought from Cebu, one of the Philippine Islands, and kindly supplied by G. M. Browne, Esq., of Liverpool.

Spores of Preissia commutata, exhibited.—Dr. D. Moore showed spores of *Preissia commutata*, found by him in one of the tanks in the Victoria House at the Botanic Garden, and which he was momentarily puzzled to find in water; but the circumstance was explained by his finding the plant established hard by.

Muscle Spindle-shaped Cells, exhibited.—Mr. B. Wills Richardson exhibited a slide containing several isolated organic muscle spindle-shaped cells, slightly stained by carmine. He observed that although, in almost all the cells, the nucleus of each was visible, it did not appear to be so wide as represented in the organic muscle-cells as illustrated in many works on histology.

A new Species of Staurastrum, exhibited.—Mr. Archer showed a minute new species of *Staurastrum* with its zygospore; but without a complete techninal description, if not a figure, further reference be of no use.

Specimens of Isotoma arborea, remarkable for the vast quantities in which it occurred, exhibited.—Mr. A. G. More exhibited a minute creature, evidently belonging to the *Collembola* of Lubbock, which had been found in amazing quantities beneath the floor of a greenhouse; they were removed by thousands.

Dr. E. P. Wright, on a casual examination, seemed to think they were specimens, in almost all stages of coloration, of *Isotoma arborea.*

Trichophyton tonsurans, exhibited.—Dr. Arthur Barker exhibited a slide of *Trichophyton tonsurans*, and drew attention to its myceloid growth, occasionally presenting a somewhat torulose appearance.

Microscopical Photographic Negatives, exhibited.—Mr. Woodworth showed some excellent photographic negatives taken by himself of several microscopic objects—diatoms, insects, various sections, &c. —mounted for employment with the oxyhydrogen lantern; they were of great sharpness and accuracy of detail.

Double-spored or Twin-spored form of Cylindrocystis Brébissonii? shown.—Mr. Archer showed the conjugated state of a Cylindrocystis, which, if taken in the unconjugated condition, would be at once pronounced to be *Cylindrocystis Brébissonii*, but the zygospore, or rather zygospores, for they were *twin*, were so remarkably like those of *Penium didymocarpum*, Lundell, as scarcely to differ, except in being notably larger. Thus, these very singular examples suggest one or other of two conclusions—*either* that *Cylindrocystis Brébissonii* conjugates in two ways; at one time with a single spore, as often met with, and as figured by de Bary ('Untersuchungen ueber die Familie der Conjugaten,' T. VII, fig. 12, 13, 16, 17), and at another time with a double spore or twin spores, like *Penium didymocarpum*, Lundell—*or* there is a distinct species of *Cylindrocystis*, so like *Cylindrocystis Brébissonii* that observation as yet furnishes no tangible distinction in the unconjugated state, but which differs in the conjugated state therefrom. *Penium didymocarpum*, Lundell, so like in its conjugated state to the present examples, is a perfectly distinct plant *per se;* it is very rare in Ireland (found as yet only at Connemara, and once or twice conjugated, quite agreeing with Lundell's figure); on the other hand, *Cylindrocystis Brébissonii* is extremely common, and, indeed, frequently met with conjugated (in the single-spored way). To the former view, for the present, Mr. Archer was inclined to lean, that is, that *C. Brébissonii* conjugates *both ways*, but in the double way far more rarely; indeed, it was the first time he had ever noticed its occurrence.

28*th May*, 1874.

Hypertrophied Bark of Ulmus campestris.—Dr. E. Perceval Wright exhibited a section of the bark of *Ulmus campestris*, from Killarney, remarkably hypertrophied, producing on the small underwood stems several irregular, elevated, horizontal ribs of considerable height, and forming almost a disconnected or independent growth of extremely exuberant degree of development.

Nitzschia grandis, Kitton, *and Amphora lanceolata*, Cleve, *exhibited.*—Rev. E. O'Meara presented a slide containing a new species of *Nitzschia*, mounted by our corresponding member, Mr. Kitton, and named by him *N. grandis.*—He also showed *Amphora lanceolata*, Cleve ('Diat. fr. Spitzbergen'), and which Mr. O'Meara had found in great abundance in gatherings made at Spitzbergen by Rev. Mr. Eaton.

Artificial Production of Crystals of Oxalate of Lime.—Professor Tichborne showed some artificial crystals of oxalate of lime. These were of various shapes, but the well-known typical crossed octohedra were there in great abundance. The point of interest in connection with them was the ease with which they could be formed. A deep glass was taken, into which was placed a very thin layer of a saturated solution of chloride of calcium and a piece of marble; floating upon this was put a considerable depth of glycerine, and again on the surface of this a weak solution of oxalate of ammonia; the whole was then placed on one side in a situation where it would not be disturbed for a space of two months. Diffusion of the liquids took place, and on examination a fine crop of this crystal was found, capable of being mounted in the ordinary manner.

The Connection of the Peritoneal "Endothelial" Cells.—Mr. B. Wills Richardson exhibited several preparations of his own mounting to illustrate the connection of the peritoneal "endothelial" cells with one another. The specimens were prepared after the nitrate of silver process, which had been very successful. The so-called cementing substance connecting the margins of the endothelial plates with one another was almost black, having the appearance of a beautiful network. This was very well seen on the under surface of the abdominal wall of the mouse and in the peritoneal surface of a rabbit's bladder. The preparations were submitted to the action of the nitrate of silver solution (one grain of nitrate to every drachm and a half of distilled water) for two minutes, then carefully washed in distilled water, and afterwards submitted to the action of bright sunlight for about one minute, when they were ready for mounting in glycerine.—Mr. Richardson also exhibited a carmine-stained piece of the desquamated epithelium of the frog, and observed that he had failed in staining the cementing substance connecting the cells together with the nitrate of silver; at least the nitrate would not differentiate this substance by tinting it of a darker colour than the cells.

On the Structure of Anorthite Dolerite.—Professor Hull, F.R.S., exhibited a translucent thin slice of anorthite dolerite from Carlingford mountain, which was apparently similar in structure and composition to the dolerites of the north of Ireland, except that the usual labradorite felspar was replaced by anorthite. The determination of this felspar had been made by the Rev. Professor Haughton, who found, from the large proportion of lime, that it was anorthite, which he attributed to its proximity, when in a state of fusion, to the carboniferous limestone of the district. In composition it consists of a base of augite, in which the felspar is very definitely developed in the form of distinct crystals, or groups of crystals; with a low power, and under polarized light these display a very rich play of colours, some of ruby tint being particularly beautiful, while the parallel bands and fine lines, characteristic of the triclinic group of felspars, are strongly pronounced. Along with these are a few opaque grains of magnetite, and one or two large rounded grains, with a fainter play of colours than in the case either of the felspars

or augite, which are, in all probability, grains of olivine or pseudomorphic after that mineral. The rock is largely crystalline, granular, and has been called "anorthite-syanite;" but, as the basic mineral is augite rather then hornblend, and as silica is altogether absent, the name already applied to it seems the most appropriate.

Microscopical Structure of Spines of Centrostephanus Rodgersii, Agassiz.—Mr. H. W. Mackintosh exhibited transverse sections of spines of *Centrostephanus Rodgersii*, A. Agass. In this form the spines, though agreeing in being hollow and deep crimson in colour, differ considerably in external appearance and internal structure. One set are fusiform and longitudinally costate, and, in section, show the central cavity to be surrounded by a network of considerable extent, which sends out short prolongations to bound the wedge-shaped solid pieces, whose external rounded projections form the surface ridges, and which show a series of striæ (like those on starch-grains of potato) surrounding a more or less distinct point situated near the base of the wedge; the interspaces of the reticulations are irregular, both in shape and disposition, except along the line joining the bases of the solid pieces with the centre, where they are tolerably uniformly quadrilateral, and placed directly behind one another. The other form of spines tapers gradually from the base to the point; they are abruptly serrate, and have the central cavity much wider; they display in section a series of urn-shaped solid pieces (with thin striæ, much less distinct than in the wedges), whose stems arise from a narrow ring surrounding the central space, and are joined by an extremely irregular band of reticulations; the solid pieces are also united by broad solid bands irregularly placed.

Sporangium-like Structure in Polyactis.—Mr. Pim showed a seemingly peculiar condition of a form of *Polyactis*, presenting, supported on branches of the hypha, what appeared to be fruit-like or sporangium-like bodies of a globular figure, in which he believed he had seen a division of the contents into a number of spores. The present specimen had somewhat altered since being put up, and these bodies now offered the appearance of globular mucous heads to the supporting stipes, with a number of minute granules or corpuscles within.

Pentastomum proboscideum, Diesing, *exhibited.*—Dr. A. Macalister exhibited a specimen of *Pentastomum* from the lung and peritoneal cavity of *Boa imperator*. The species is closely allied to, if not identical with, *Pentastomum proboscideum*, Diesing. The specimens found were all females, and showed eggs in different developmental stages. He deferred any further account until he had time to examine all his specimens, and to compare them with another species of *Pentastomum* recently obtained by him from Aonyx.

Cylindrocapsa involuta, Reinsch, *new to Britain, exhibited.*—Mr. Archer showed an algal form, doubtless identical with *Cylindrocapsa involuta*, Reinsch ('Algenflora des mittleren Theiles von Franken,' p. 66, T. VI, f. 1, *a*, *b*, *c*), though that author's description

his plant appears not quite complete, as he omits to mention (admitting the identity) that the cylindrical hyaline outer envelope of the generally but few, say 2 to 8 or 10, component cells is closed at both extremities, rounded off at one—the upper—and produced and (at least temporarily) attached to other objects at the other, or lower, extremity. This plant, therefore, simple as it appears, seems to offer a differentiation of extremities—a basal and an apical. The examples agreed with Reinsch's in the dimensions of the cells themselves, their ovate figure, and their being involved, within the outer cylindrical envelope, by a number of special hyaline investments; these, however, not seemingly uniformly *four* (as Reinsch depicts), but sometimes two, three, or four, and standing off from the cells at uneven distances. Some of the examples showed cells recently divided, quite as shown by Reinsch, enclosed in the tubular common envelope, with their longer diameter in the direction of its length, thus unlike *C. nuda*, in which the cells are placed transversely. That author does not state that the contents are not a bright, but a dull lurid green, very opaque. Thus, the *morphology* of this plant seems to point to a close affinity with *Hormospora*, which, too, has its forms with the cells longitudinally placed (*H. mutabilis* and others), and transversely (*H. transversalis*), but the filaments of *Hormospora* are bright and beautiful green, the cell-contents characteristically arranged, and they form very long filaments, seemingly unattached. But as forms or form-species (for they cannot be accounted more so long as no reproductive process is known), those referable to *Cylindrocapsa* seem quite distinct, and none more so than the form now exhibited; it seems to be very rare; Mr. Archer had never before noticed it (and now it was extremely scanty), anfl *C. nuda* had only once turned up. But whether these be mere stages of other growths —mere form-species or *permanent parthenogenetic* forms—at least, just as well as many others, constantly recurring and perfectly distinct things, such as Nägeli's genera *Apiocystis*, *Ophiocytium*, de Brébisson's *Hormospora*, &c. &c., the much more rare forms now drawn attention to, referable to *Cylindrocapsa*, are entitled to hold a place for purposes of reference until at least more may perchance be known as to their true nature and position.

INDEX TO JOURNAL

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Jn° Farlane & Erskine, Lith^{rs} Edin^{r}

EXPLANATION OF PLATE I,

Illustrating G. O. Sars's Paper on Rhabdopleura.

FIG.

1.—The animal taken out of the cell and slightly compressed, seen from the left side.
- *c.* Buccal shield.
- *d.* Tentacular arms.
- *e.* Œsophagus.
- *f.* Stomach.
- *g.* Intestine.
- *h.* Contractile cord.
- *l.* Hyaline semilunar border at base of tentacular arms.
- *m.* The under lip.
- *n.* The ciliated tubercle at the base of the tentacular arm.
- *p.* The flexor muscle of the tentacular arm.
- *q.* The buccal aperture.
- *r.* The cellular body between the end of the intestine and the œsophagus.

2.—The animal seen from the ventral side.
(Letters as in fig. 1.)

3.—The animal seen from the dorsal side.
(Letters as in fig. 1.)

4.—The anterior part of the body seen from in front; *c*, *d*, *l*, as in fig. 1.

5.—A part of a living colony magnified about sixteen times.
- *aa.* The cells with their polypides in different states of protrusion.
- *bb.* The creeping stem.
- *cc.* The buccal shield.
- *dd.* The tentacular arms.
- *ff.* The stomach.
- *g.* The intestine.
- *hh.* The contractile cord.
- *ii.* The axial cord.

6.—A piece of the creeping stem freed from adhering particles, together with the bases of the cells and their polypides mostly strongly retracted, about 20 times magnified, showing the single chambers into which the stem is divided.
- *cc.* The buccal shield.
- *ff.* The stomach.
- *hh.* The contractile cord.
- *ii.* The axial cord.

7.—The earliest stage of development noticed.

8.—A further developed polypide seen from the dorsal side; *cc*, the buccal shield; *d*, the tentacular arms; *h*, the contractile cord.

9.—The same polypide with the axial cord (*i*) seen from the ventral side.

DESCRIPTION OF PLATE II,

Illustrating Mr. C. S. Tomes's Paper on the Development of the Teeth, in an Armadillo.

FIG.

1.—Section through the lower jaw of a fœtal calf, 6 inches long.

a. Meckel's cartilage.
b. Dentine germ.
c. Enamel organ.
d. Process connecting the enamel germ with the deep layer of the oral epithelium.
e. Epithelium heaped up over the situation of the developing tooth.
f. Enamel germ of the successional permanent tooth.

2.—From the lower jaw of a fœtal armadillo (*Tatusia Peba*) $1\frac{1}{2}$ inches long.

b. Dentine germ.
c. Enamel germ.

3 and 4.—From a fœtal armadillo (*T. Peba*) 3 inches long.

b. Dentine germ.
c. Enamel germ.
f. Germ of permanent tooth.
g. Extremity of the cornua of the enamel germ.
h. Thin cap of formed dentine.

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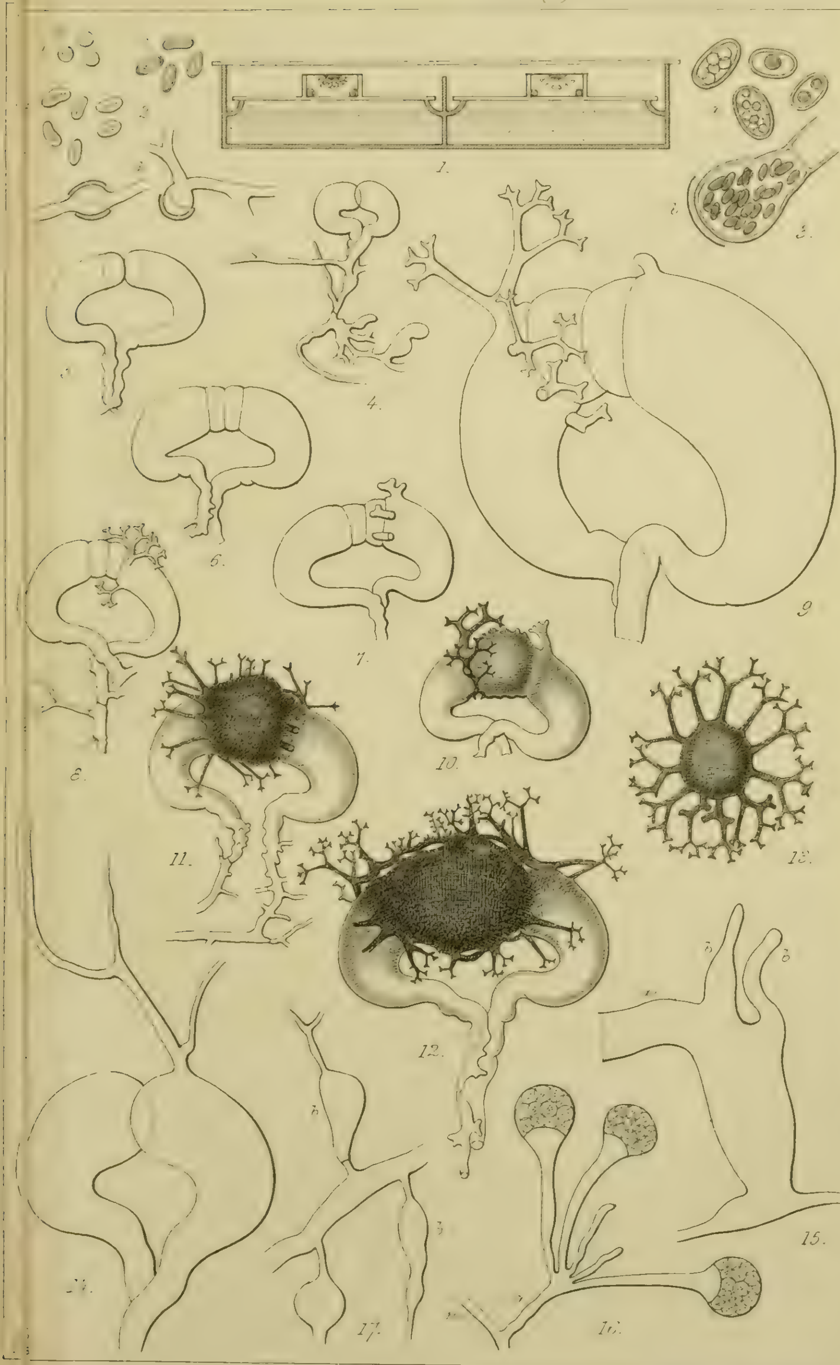

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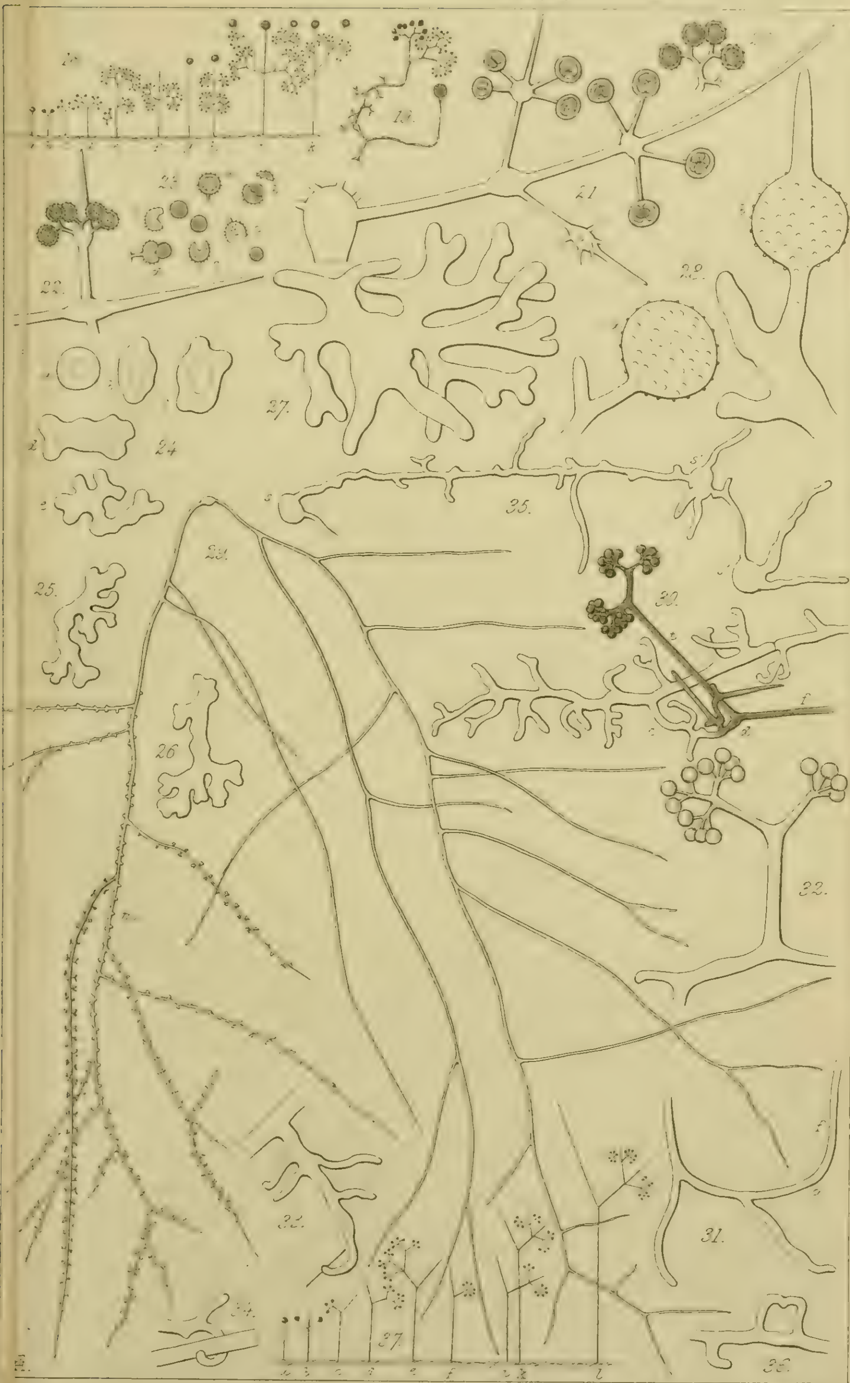

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DESCRIPTION OF PLATES III & IV,

To illustrate MM. Van Tieghem and Le Monnier's Researches on the Mucorini.

Fig. 1.—Section of a zinc box for cell-cultures; it is arranged to hold two rows of slides, and is closed above by a glass plate; the bottom is covered with wet sand or moistened plaster.

Phycomyces nitens.

Fig. 2.—*a*, spherical spores from small sporangia, the central granules are yellow; *b*, fresh, elongated, ellipsoidal or concavo-convex spores from large sporangia; *c*, older spores, the wall has a double contour; *d*, older spores germinating with rupture of the exospore (× 160).

Fig. 3.—*a*, spores in process of alteration in a moist medium, the protoplasm condenses into nodules; *b*, a germinating hypha in process of destruction, its base still inclosed in the epispore is partitioned off, and the contained protoplasm is condensed into oval corpuscles (× 320).

Figs. 4—12.—Successive stages in the development of a zygospore; 4—6, before the development of the processes (× 40); 7, 8, processes making their appearance from above downwards upon one of the arcuate cells (× 40); 9—11, their appearance upon the other arcuate cell simultaneously with the increase in the size of the zygospore (9 × 120, 10 and 11 × 40), in fig. 11 a slight traction has been applied to the two conjugating filaments; 12, mature zygospore enveloped by the dichotomous processes, many of which are broken (× 50).

Fig. 13.—Side of attachment of an arcuate cell with processes radiating all round (× 40).

Fig. 14.—"Vice" arrested in its development; the first process is developed in its ordinary position, but has been prolonged and developed into ordinary mycelial hyphæ (× 120).

Fig. 15.—Base of a sporangiferous hypha (*a*); *bb*, sterile branches (cell-culture) (× 120).

Fig. 16.—Group of three small sporangia inserted with two sterile branches on a branch (*a*) of the mycelial hypha (*m*) (cell-culture) (× 120).

Fig. 17.—Basal dilatations of lateral branches (*b*, *b*) of a mycelial hypha (cell-culture) (× 120).

Thamnidium elegans.

Fig. 18.—Different stages of the fructification.

Fig. 19.—Mycelium which has produced—(i) a large sporangium, (ii) a

dichotomy of eight small sporangia, (iii) a secondary lateral dichotomy of monosporic sporangioles.

Fig. 20.—Monosporic sporangioles with granular walls (× 250).

Chætostylum Fresenii.

Fig. 21.—Lateral branch inserted, with numerous others, on the top of a hypha; it terminates in a point, and bears two false verticils of branchlets. The lower sporangioles are of the fourth, the upper of the third order (× 250).

Chætocladium Jonesii.

Fig. 22.—Fruiting hypha terminating in a point, and bearing upon a middle dilatation monosporic sporangia with granular walls and simple or dichotomous pedicels (× 270).

Fig. 23.—*a*, a monosporic sporangium, with a portion of its pedicel; *b*, one ruptured by pressure, showing the inclosed smooth spore; *c*, *c*, spores entirely freed from their sporangia; *d*. a spore escaping from its sporangium at the commencement of germination (× 270).

Figs. 24—27.—Successive stages of germination.

Fig. 28.—Granular-walled balloon-like bodies terminating some of the branches (× 270).

Fig. 37.—Successive stages of fructification in cell-culture.

Chætocladium Brefeldii.

Fig. 29.—Mycelium proceeding from a single spore after sixty-seven hours; the lateral processes are only figured on a single branch (*m*).

Fig. 30.—End of a principal branch after five and a half days: a lateral process (*c*) has developed a sporangiferous branch (*d*), of which the aerial portion is shaded; it bears fertile branches (*t* and *f*), and also sterile ones, at its base (× 190).

Fig. 31.—Extremity of a hypha after four and a half days' culture; one of its branches (*a*) is prolonged into an aerial filament, bearing laterally numerous groups of ripe sporangia (× 190).

Fig. 32.—One of these groups of monosporic sporangia (× 400).

Figs. 33, 34.—Lateral processes in contact with a hypha of *Mucor Mucedo* (× 400).

Fig. 35.—Three spores (*s*, *s′*, *s′*) which have germinated, and the hyphæ of which have fused (× 190).

Fig. 36.—Two branches of a hypha which have fused, forming a loop (× 190).

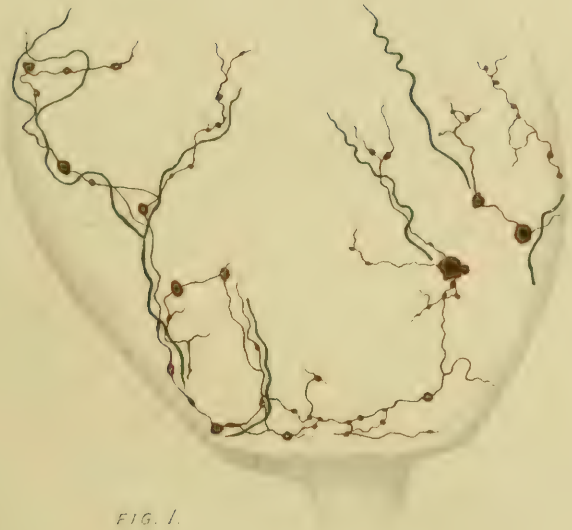

FIG. 1.

FIG. 2.

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DESCRIPTION OF PLATES V & VI.

Illustrating Mr. Darwin's paper on the Anatomy of the Sympathetic Ganglia of the Bladder in their Relation to the Valvular System.

PLATE V.

FIGS.

1.—Posterior surface of the bladder of a young dog, stained with chloride of gold, seen under a very low power. It shows the distribution of nerve-trunks and ganglia in relation to large branches of blood-vessels. The blood-vessels are coloured green, the nerve-trunks and ganglia are purple.

2.—From a dog's bladder stained in chloride of gold, showing an artery and vein with the accompanying plexus of nerve-trunks and ganglia. Hartnack, No. 4.

A_1. Artery (red).

A_2. Vein (blue).

B, B. Nerve-trunks (purple).

C, C. Ganglia (purple).

PLATE VI.

FIGS.

3.—From the bladder of a rabbit, stained with chloride of gold, showing an artery and two ganglia. The larger ganglion (I) is surrounded by a plexus of capillaries. A nerve-trunk from each ganglion passes down to supply the artery. Hartnack, No. 5.

A. Artery.

B, B. Nerve-trunks.

C, C. Ganglia (I, and II).

a. The place where the nerve-trunks disappear in the adventitia.

e f. Transverse line at which the nerve-trunk from ganglion I is supposed to be interrupted.

B_1 and B_1. Nerve-trunks which ought to be continuous with each other, and to connect the ganglia I and II together.

DD. Capillaries.

4.—Nerve-trunk arising from ganglion II of fig. 3, and supplying the artery A of the same figure. Hartnack, No..2.

A. Artery.

B. Nerve-trunk.

a. Nerve-fibres ending in the artery.

D. Capillaries.

5.—From the bladder of a dog stained with chloride of gold. Hartnack, No. 5.

A. Artery.

B_1 and a_1. Nerve-trunks arising from ganglia situated close together on a nerve-trunk not shown in the figure.

a. Nerve-fibres ending in the adventitia.

6.—Ganglion situated on a large nerve-trunk, with smaller accessory ganglion, from the bladder of a dog stained with chloride of gold. Hartnack, No. 5.

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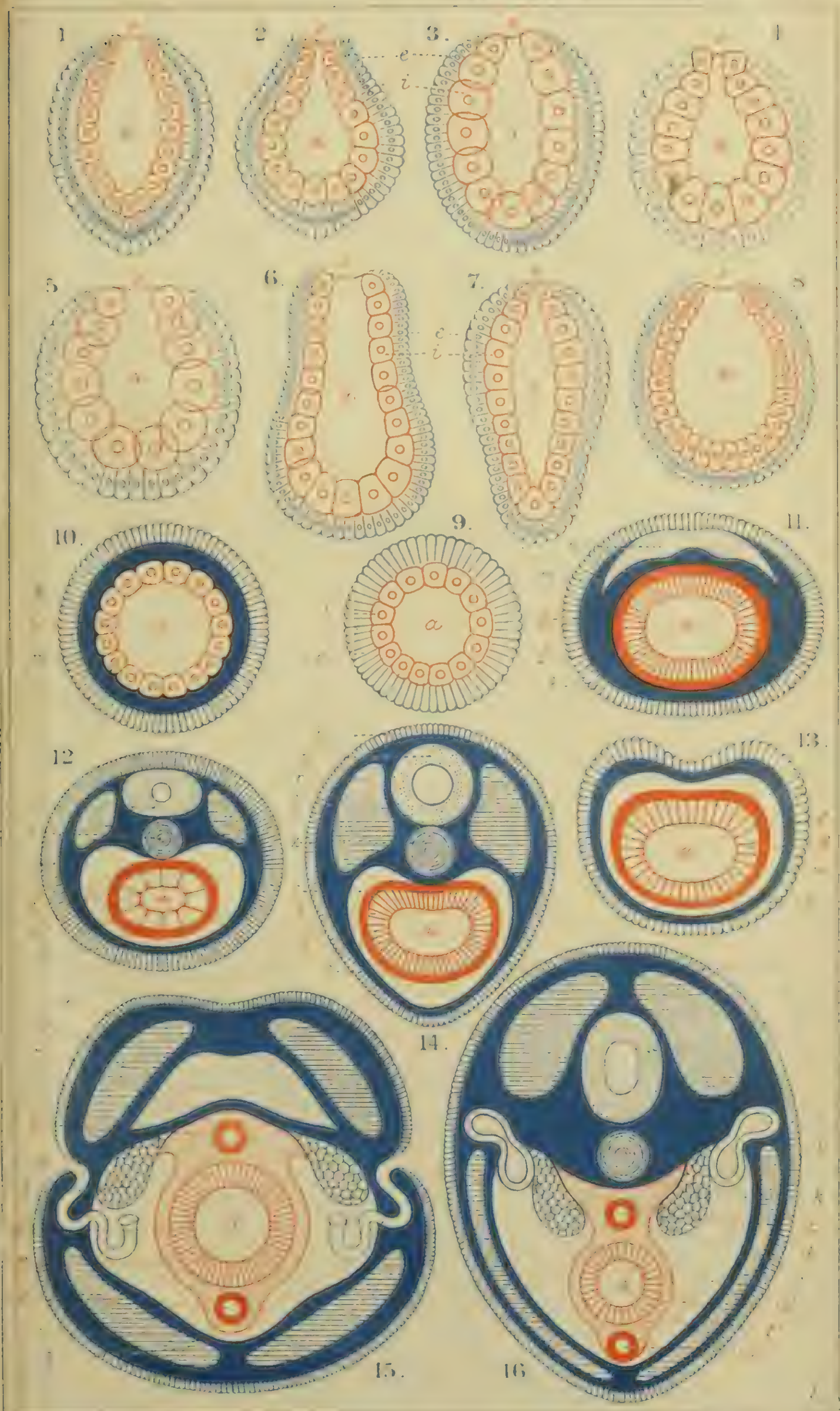

1
2
3.
4
e
i
5
6.
7.
8
c
i
9.
10.
11.
a
12
13.
14.
15.
16

DESCRIPTION OF PLATE VII,

Illustrating Ernst Haeckel's memoir on the Gastraea-Theory, the Phylogenetic Classification of the Animal Kingdom, and the Homology of Germ-Lamellæ. Translated by E. Perceval Wright.

Plate VII contains a schematic section through the young stages of representatives of all the different phyla of Metazoa, and will give a clear idea, not only of the homology of both primary germ-lamellæ, but also of the origin of the four secondary germ-lamellæ. Figs. 1—8 are schematic longitudinal sections; figs. 9—16, schematic cross sections. In all the figures the primary inner germ-lamella (ventral lamella, entoderm, vegetative germ-lamella), including the parts derived therefrom, is indicated by the red colour; while, on the other hand, the primary outer germ-lamella (dermal lamella, exoderm, animal germ-layer) is indicated by blue. The letters are throughout the same.

a. Primitive intestine (progaster); primitive intestinal tube.
b. Ventral lateral hollow muscles.
c. Cœlom (body-cavity or pleuro-peritoneal cavity).
d. Intestinal glandular layer (mykogastral layer).
e. Dermal layer (exoderm); outer primary germ-lamella; intestinal layer.
f. Fibro-intestinal layer (inogastral layer).
h. Neuro-dermal layer.
i. Gastral layer (entoderma); inner primary germ-lamella, dermal layer.
k. Germinal glands (appendages to the sexual glands).
l. Skin (corium).
m. Fibro-dermal layer (inodermal layer).
n. Primitive brain (medullary canal).
o. Primitive mouth (prostoma); primitive oral opening.
r. Dorsal lateral hollow muscles.
t. Dorsal intestinal vessels (aorta).
u. Primitive kidneys (excretions-canal).
x. Chorda dorsalis or vertebral column.
z. Ventral intestinal vessel (heart).

Figs. 1—8 represent schematic longitudinal sections of gastrula from eight diverse animal forms, *i.e.*—

Fig. 1.—Gastrula of Sponges (*Olynthus*).
Fig. 2. „ „ Corals (*Actinia*).
Fig. 3. „ „ Accœlomi (*Turbellaria*).
Fig. 4. „ „ Tunicata (*Ascidia*).
Fig. 5. „ „ Mollusca (*Limnæus*).
Fig. 6. „ „ Asterida (*Uraster*).
Fig. 7. „ „ Crustacea (*Nauplius*).
Fig. 8. „ „ Vertebrata (*Amphioxus*).

Figs. 9—16 represent schematic cross-sections through representatives of eight different types, *i. e.*—

Fig. 9.—Through a simple Sponge (*Olynthus*) or a simple Hydromedusa (*Hydra*). The wall of the primitive intestine remains (as in Gastrula) for life only by the two primary germ-lamellæ.

Fig. 10.—Through a simple Acalepha (Hydroid). Between the gastral layer (*i*) and the neuro-dermal layer (*h*) lies the fibro-dermal layer.

Fig. 11.—Through an Acœlomatous embryo (*Turbellaria*). The section goes right through the primitive brain or œsophageal ganglion (*n*). Between the neuro-dermal layers (*h*) and the intestinal glandular layers (*d*) are visible, moreover, the two fibrous lamellæ which lie compactly on one another—the outer the fibro-dermal layer (*m*), and the inner the fibro-intestinal layer (*f*).

Fig. 12.—Through an Ascidian larva, from the base of the tail, so as to put in the lowest end of the chorda (*x*) between the medullary canal (*n*) and the intestinal tube (*d*). Between the fibro-dermal layer (*m*) and the fibro-intestinal layer (*f*) the cœlom is visible.

Fig. 13.—Through an *Amphioxus* larva (compare Kowalevsky's 'Development of *Amphioxus*,' plate ii, fig. 20). The fibro-intestinal layer (*f*) is still entirely separated from the fibro-dermal layer (*m*); the entire body becomes barely formed from the four secondary germ-lamellæ.

Fig. 14.—Through an older *Amphioxus* larva. The medullary canal (*n*) has become completely unravelled out of the horny layer (*h*). The fibro-dermal layer (*m*) is blended together with the fibro-intestinal layer (*f*) in the dorsal middle line (mesenteric line), and is differentiated into the skin (*l*) and hollow muscles (*r*). Between the intestinal tube and the unravelled-out medullary canal (*n*) is seen the commencement of the chorda (*x*).

Fig. 15.—Through a worm-embryo (cephalic segment of an Annelid). Between the dorsal (*r*) and ventral (*b*) longitudinal muscles are interposed the primitive kidneys (segmental organs, *u*) from the outer dermal layer throughout the body-cavity (*c*). On the upper side of the primitive intestine (*a*) is the dorsal longitudinal vessel (*t*), below the same the ventral longitudinal vessel appears (*z*), both enclosed in the fibro-intestinal layer (*f*).

Fig. 16.—Through a vertebrate embryo (central section of a fish) Between the dorsal (*r*) and ventral (*b*) hollow lateral muscles is interposed the first appearance of the primitive kidney system (*u*) from the skin throughout the body-cavity. On the upper surface of the primitive intestine (*a*) is the primordial aorta (*t*), below the same the outline of the heart (or the bulbus arteriosus, *z*) is to be seen, both enclosed in the fibro-intestinal layer (*f*). The only real difference between the typical transverse section of the vertebrate body and that of the worm-body (fig. 15) is that in the former, between the medullary tube (*n*) and the primitive intestine (*a*), the chorda (*x*) makes its appearance.

JENA; 29th September, 1873.

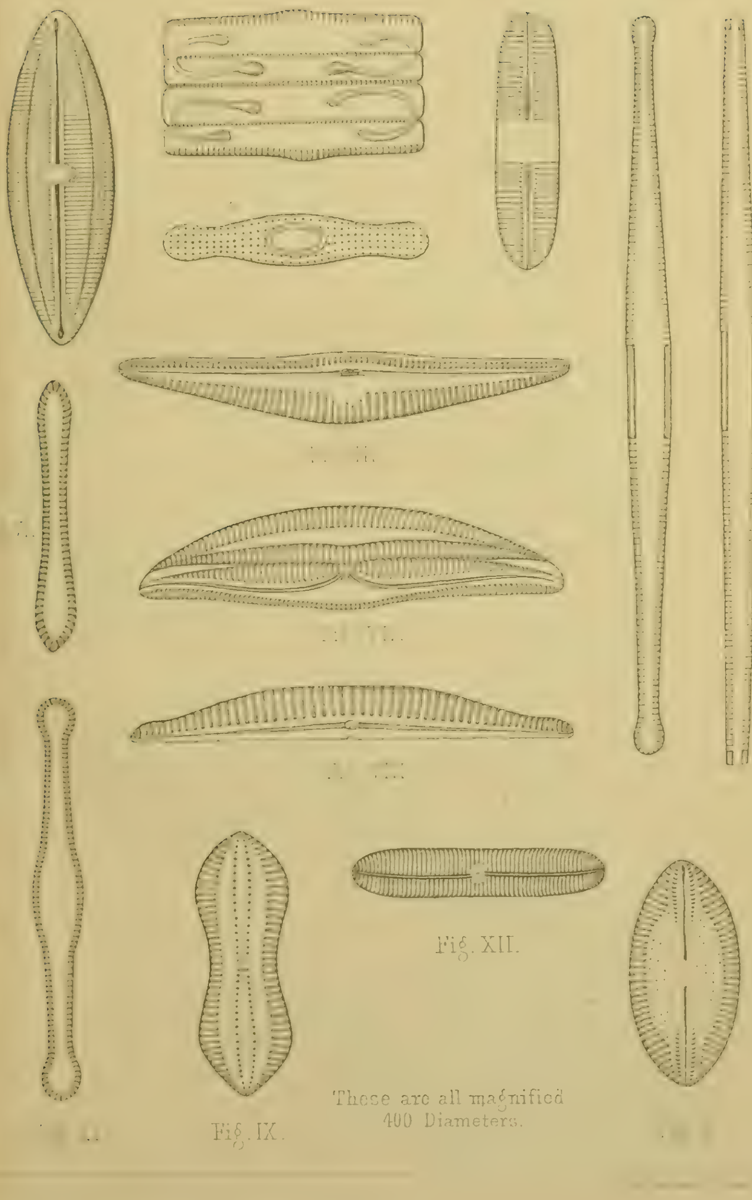
Fig. XII.
Fig. IX.
These are all magnified
400 Diameters.

DESCRIPTION OF PLATE VIII,

To illustrate the Rev. O'Meara's paper on Diatomaceæ from Spitzbergen.

Fig.

1. *Navicula arctica*, Cleve.
2. *Grammatophora arctica,* Cleve; *b,* side view.
3. *Amphora lanceolata,* Cleve.
4. *Navicula pinnularia,* Cleve.
5. *Synedra Kamscatica,* Grun.; *b,* side view.
6. *Asterionella Cleviana*, n. s., O'Meara.
7. *Amphora Eatoniana,* n. s., O'Meara.
8. *Amphora Leighsmithiana,* n. s., O'Meara.
9. *Navicula Archeriana*, n. s., O'Meara.
10. *Navicula nebulosa,* var.
11. *Synedra arctica*, n. s., O'Meara.
12. *Navicula Auklandica*, Grun.?

DESCRIPTION OF PLATE IX,

Illustrating Mr. G. Busk's paper on *Clavopora Hystricis*—a New Polyzoon belonging to the Family Halcyonelleæ.

Fig 1. Magnified view of the entire growth. (*a*) One of the zooœcia.

„ 2. A portion of the stem, showing the peculiar fibres.

„ 3. A portion of the capitulum, magnified to the same degree, showing one of the zooœcia containing a polypide.

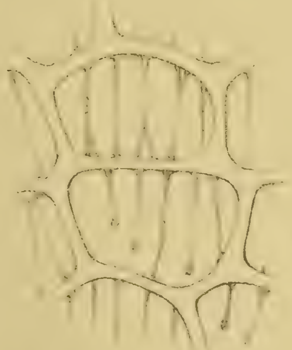

Fig. 2

Fig. 1.

Fig. 3

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10.
11.

JOURNAL OF MICROSCOPICAL SCIENCE.

DESCRIPTION OF PLATES X & XI.

Illustrating Dr. Farlow's paper on an Asexual Growth from the Prothallus of *Pteris cretica.*

Figs.

1– 3.—Different forms of the prothallus of *Pteris cretica,* with antheridia and root hairs on their lower portions.

a. Scalariform duct.

b. First leaf.

r. Root.

s. Stem bud.

4.—Vertical section of prothallus somewhat less advanced than in fig. 3; the letters indicate the same structures as before.

5.—Prothallus producing two leaves side by side; *a,* scalariform ducts, *b,* leaf from upper, *b′,* leaf from under side.

6.—Longitudinal section of prothallus in fig. 1, in the direction of the arrows.

7.—Longitudinal section parallel to *y* in fig. 6, and more highly magnified.

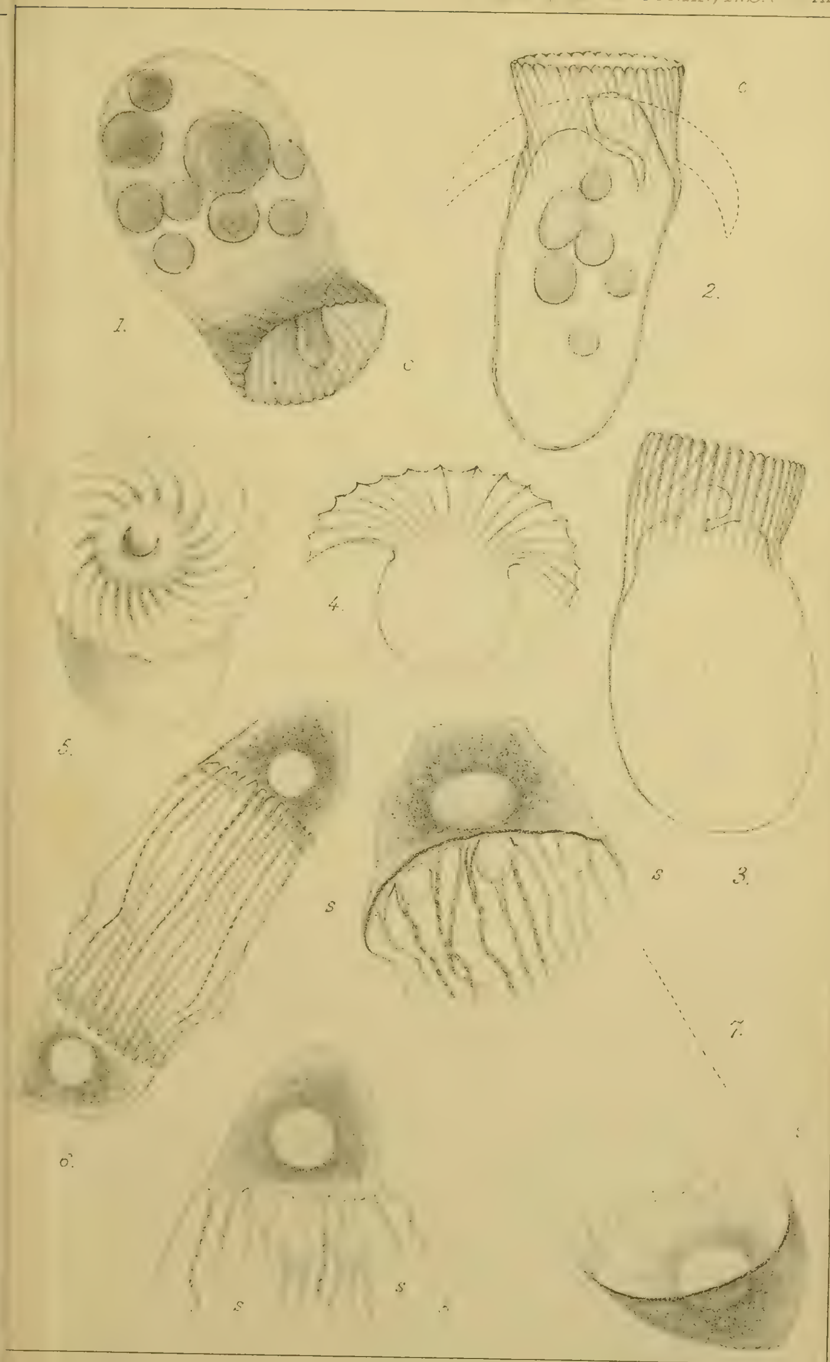
z. Two of the archegonium-like group of four cells, which are seen to have no immediate relation with the subjacent scalariform ducts.

8.—Transverse section of the prothallus in fig. 4 at the point x; this is figured in the plate with the under side of the prothallus uppermost.

9.—Longitudinal section of prothallus in fig. 2 in the direction of the arrows.

10.—Longitudinal section of a prothallus p p, similar to fig. 4, made through the place of origin by budding of a young plant; the other letters as in figs. 1—3.

11.—More magnified view of a portion of the prothallus in fig. 5.



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EXPLANATION OF PLATE XII,

Illustrating Mr. Ray Lankester's papers on "A new type of Infusoria," and on "The Heart of *Appendicularia furcata*."

Figs.

1—3.—*Torquatella typica;* three specimens. *c.* Capitular prominence or upper lip over-hanging the mouth.

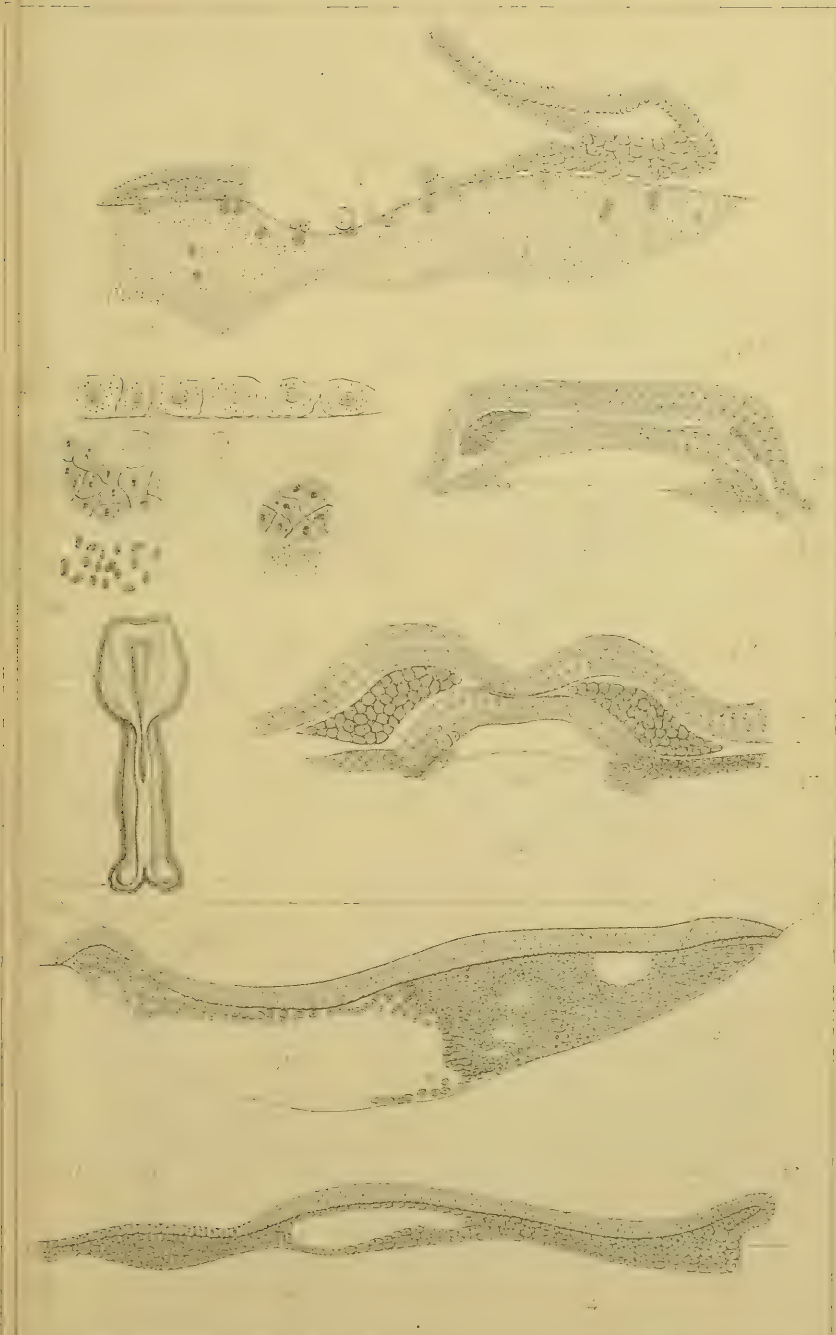
4.—The same, a side view of another specimen, as seen swimming.

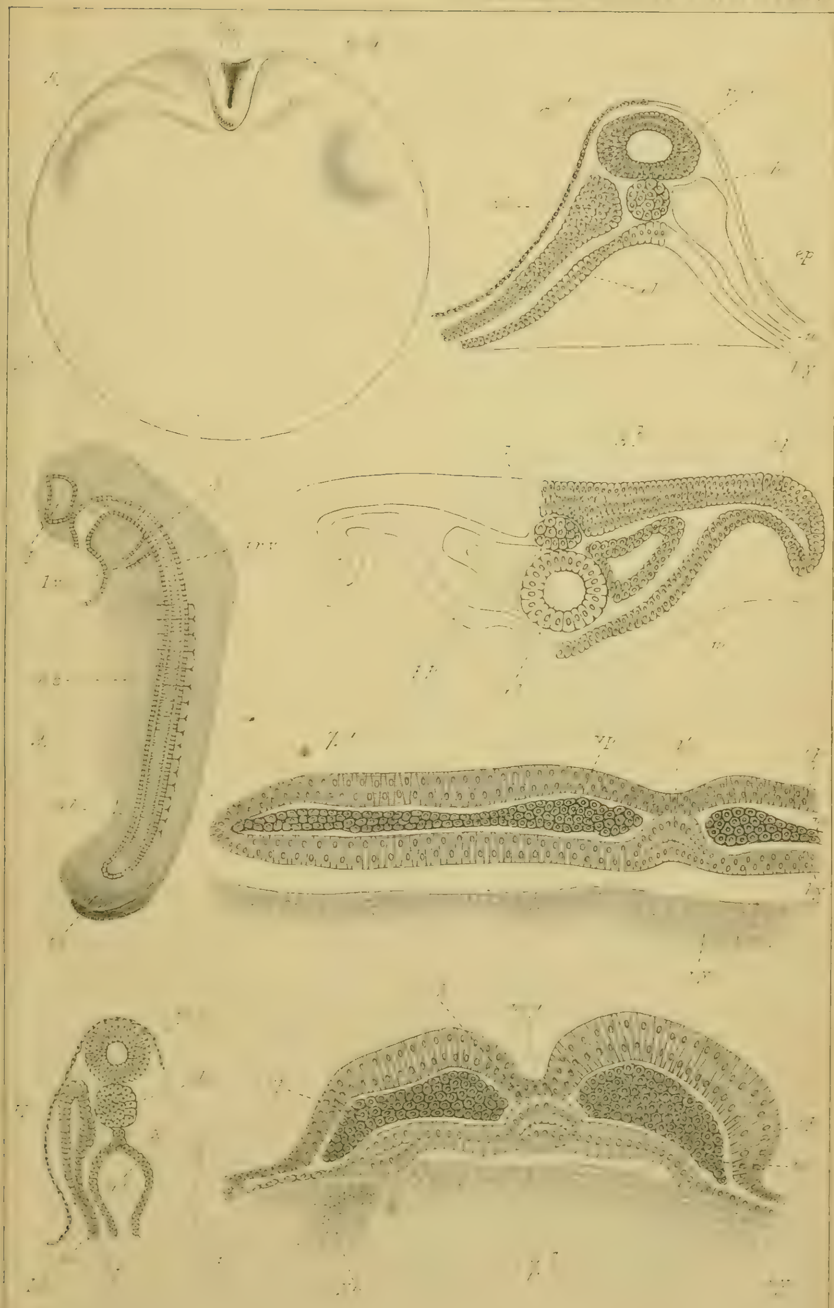
5.—The same; another specimen seen from above.

6.—Heart of young *Appendicularia furcata.*

7.—Heart of a full-grown specimen. *s.* Secondary corpuscles.

8.—One heart-cell, with out-growing fibrillæ; from another specimen. *s.* Secondary corpuscles.





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EXPLANATION OF PLATES XIII, XIV & XV,

Illustrating Mr. F. M. Balfour's Paper on the development of the Elasmobranch Fishes (Dog-fishes).

Complete List of Reference Letters.

n. Peculiar nuclei formed in the yolk.
n'. Similar nuclei in the cells of the blastoderm.
b d. Formative cell probably derived from the yolk.
n y. Network of lines present in the food-yolk.
y k. Yolk spherules.
l y. Line of separation between the blastoderm and the yolk.
e p. Epiblast.
e p'. Epidermis.
l l. Lower layer cells.
m. Mesoblast.
h y. Hypoblast.
s c. Segmentation cavity.
e s. Embryonic swelling.
e r. Embryonic rim.
e b. Line indicating the edge of the blastoderm.
m g. Medullary groove.
m c. Medullary canal.
t s. Caudal lobes.
n a. Cells which help to close in the alimentary canal, and which are derived from the yolk.
v p. Vertebral plates.
h. Head.
a l. Alimentary canal.
c h. Notochord.
c h'. Thickening of hypoblast to form the notochord.
p p. Pleuro-peritoneal cavity.
p p'. Remains of pleuro-peritoneal cavity in the head.
pr v. Protovertebræ.
so s. Stalk connecting embryo with yolk-sac.
v c, 1, 2, 3, &c. 1st, 2nd, and 3rd &c. visceral clefts.
op. Eye.
o l. Olfactory pit.
au v. Auditory vesicle.
V. Fifth nerve.
VII. Seventh nerve.
g l. Glosso-pharyngeal nerve.
v. Vagus nerve.
sp n. Spinal nerve.
s o. Somatopleure.
s p. Splanchnopleure.
x. Peculiar body underlying the notochord derived from the hypoblast.
a o. Dorsal aorta.

List of Reference Letters—continued.

ca v. Cardinal vein.
m p. Muscle-plate.
m p'. Early formed mass of muscles.
ov. Oviduct.
p ov. Projection which becomes the ovary.
w d. Wolffian duct.
p wd. Primary points of involution from the pleuro-peritoneal cavity by the coalescence of which the Wolffian duct is formed.
su.r. Supra renal body.
p n. Pineal gland.
ht. Heart.
v. Blood-vessel.

All the figures were drawn with the Camera Lucida.

Fig. 1.—Section parallel with the long axis of the embryo through a blastoderm, in which the floor of the segmentation cavity (*s c*) is not yet completely lined by cells. The roof of the segmentation cavity is broken. (Magnified 60 diam.) The section is intended chiefly to illustrate the distribution of nuclei (*n*) in the yolk under the blastoderm. One of the chief points to be noticed in their distribution is the fact that they form almost a complete layer under the floor of the segmentation cavity. This probably indicates that the cells whose nuclei they become take some share in forming the layer of cells which subsequently (*vide* fig. 4) forms the floor of the cavity.

Fig. 2.—Small portion of blastoderm and subjacent yolk of an embryo at the time of the first appearance of the medullary groove. (Magnified 300 diam.)

The specimen is taken from a portion of the blastoderm which will form part of the embryo. It shows two large nuclei of the yolk (*n*) and the network in the yolk between them; this network is seen to be closer around the nuclei than in the intervening space. The specimen further shows that there are no areas representing cells around the nuclei.

Fig. 3.—Section parallel with the long axis of the embryo through a blastoderm, in which the floor of the segmentation cavity is not yet covered by a complete layer of cells. (Magnified 60 diam.)

It illustrates (1) the characters of the epiblast, (2) the embryonic swelling (*e s*), (3) the segmentation cavity (*s c*). It should have been drawn upon the same scale as fig. 4; the line above it represents its true length upon this scale.

Fig. 4.—Longitudinal section through a blastoderm at the time of the first appearance of the embryonic rim, and before the formation of the medullary groove. (Magnified 45 diam.)

It illustrates (1) the embryonic rim, (2) the continuity of epiblast and hypoblast at edge of this, (3) the continual differentiation of the lower layer cells, to form, on the one hand, the hypoblast, which is continuous with the epiblast, and on the other the mesoblast, between this and the epiblast; (4) the segmentation cavity, whose floor of cells is now completed.

N.B.—The cells at the embryonic end of the blastoderm have been made rather too large.

Fig. 5.—Surface view of the blastoderm shortly after the appearance of the medullary groove. To show the relation of the embryo to the blastoderm.

FIG. 6 *a* and *b*.—Two transverse sections of the same embryo, shortly after the appearance of the medullary groove. (Magnified 96 diam.)

a. In the region of the groove. It shows (1) the two masses of mesoblast on each side, and the deficiency of the mesoblast underneath the medullary groove; (2) the commencement of the closing in of the alimentary canal below, chiefly from cells (*n a*) derived from the yolk.

b. Section in the region of the head where the medullary groove is deficient, other points as above.

FIG. 7 *a* and *b*.—Two transverse sections of an embryo about the age or rather younger than that represented in fig. 5. (Magnified 96 diam.)

a. Section nearer the tail; it shows the thickening of the hypoblast to form the notochord (*ch′*).

In *b* the thickening has become completely separated from the hypoblast as the notochord. In *a* the epiblast and hypoblast are continuous at the edge of the section, owing to the section passing through the embryonic rim.

FIG. 8—Surface view of a spatula-shaped embryo. The figure shows (1) the flattened head (*h*) where the medullary groove is deficient, (2) the caudal lobes, with a groove between them; it also shows that at this point, the medullary groove has become roofed over and converted into a canal.

FIG. 8 *a*.—Transverse section of fig. 8, passing through the line *a*. (Magnified 90 diam.) The section shows (1) the absence of the medullary groove in the head and the medullary folds turning down at this time instead of upwards; (2) the presence of the pleuro-peritoneal cavity in the head (*p p′*); (3) the completely closed alimentary canal (*a l*).

FIG. 8 *b*.—Transverse section of fig. 8, through the line *b*. (Magnified 90 diam.) It shows (1) the neural canal completely formed; (2) the vertebral plates of mesoblast not yet split up into somatopleure and sphanchnopleure.

FIG. 9.—Side view of an embryo of the Torpedo, seen as a transparent object a little older than the embryo represented in fig. 8. (Magnified 20 diam.) The internal anatomy has hardly altered, with the exception of the medullary folds having closed over above the head and the whole embryo having become more folded off from the germ.

The two caudal lobes, and the very marked groove between them, are seen at *t s*. The front end of the notochord became indistinct, and I could not see its exact termination. The epithelium of the alimentary canal (*a l*) is seen closely underlying the notochord and becoming continuous with the epiblast at the hind end of the notochord.

The first visceral cleft (I *v c*) and eye (*o p*) are just commencing to be formed, and the cranial flexure has just appeared.

FIG. 10.—Section through the dorsal region of an embryo somewhat older than the one represented in fig. 9. (Magnified 96 diam.)

It shows (1) the formation by a pinching off from the top of the alimentary canal of a peculiar body which underlies the notochord (*x*); (2) the primitive extension of the pleuro-peritoneal cavity up to the top of the vertebral plates.

FIG. 11 *a*, *b*, and *c*.—Three sections closely following each other from an embryo in which three visceral clefts are present; *a* is the most anterior of the three. (Magnified 96 diam.) In all of these the muscle-plates are shown at *m p*. They have become separated from the lateral plates in *b* and *c*, but are still continuous with them in *a*. The early formed mass of muscles is also shown in all the figures (*m p′*).

The figures further show (1) the formation of the spinal nerves (*sp n*) as

small bodies of cells closely applied to the upper and outer edge of the neural canal.

(2) The commencing formation of the cells which form the axial skeleton from the inner (splanchnopleuric) layer of the muscle-plate. Sections *b* and *c* are given more especially to show the mode of formation of the oviduct (*ov*).

In *b* it is seen as a *solid knob* (*ov*), arising from the point where the somatopleure and splanchnopleure unite, and in *c* (the section behind *b*) of a *solid rod* (*ov*) closely applied to the epiblast, which has grown backwards from the knob seen in *b*.

N.B.—In all three sections only one side is completed.

Fig. 12 *a* and *b*.—Two transverse sections of an embryo just before the appearance of the external gills. (Magnified 96 diam.)

In *a* there is seen to be an involution on each side (*p w d*), while *b* is a section from the space between two involutions from the pleuro-peritoneal cavity, so that the Wolffian duct (at first solid) (*w d*) is not connected as in *a* with the pleuro-peritoneal cavity. The further points shown in the sections are—

(1) The commencing formation of the spiral valve (*a l*).

(2) The suprarenal body (*su r*).

(3) The oviduct (*ov*), which has acquired a lumen.

(4) The increase in length of the muscle-plates, the spinal nerves, &c.

Fig. 13.—Section through the dorsal region of an embryo in which the external gills are of considerable length. (Magnified 40 diam.) The chief points to be noticed:

(1) The formation of the Wolffian body by outgrowths from the Wolffian duct (*wd*).

(2) One of still continuing connections (primitive involutions) between the Wolffian duct and the pleuro-peritoneal cavity (*p w d*).

(3) The oviduct largely increased in size (*ov*).

N.B.—On the left side the oviduct has been accidentally made too small.

(4) The growth downwards of the muscle-plate to form the muscles of the abdomen.

(5) The formation of an outgrowth on each side of the mesentery (*p ov*), which will become the ovary.

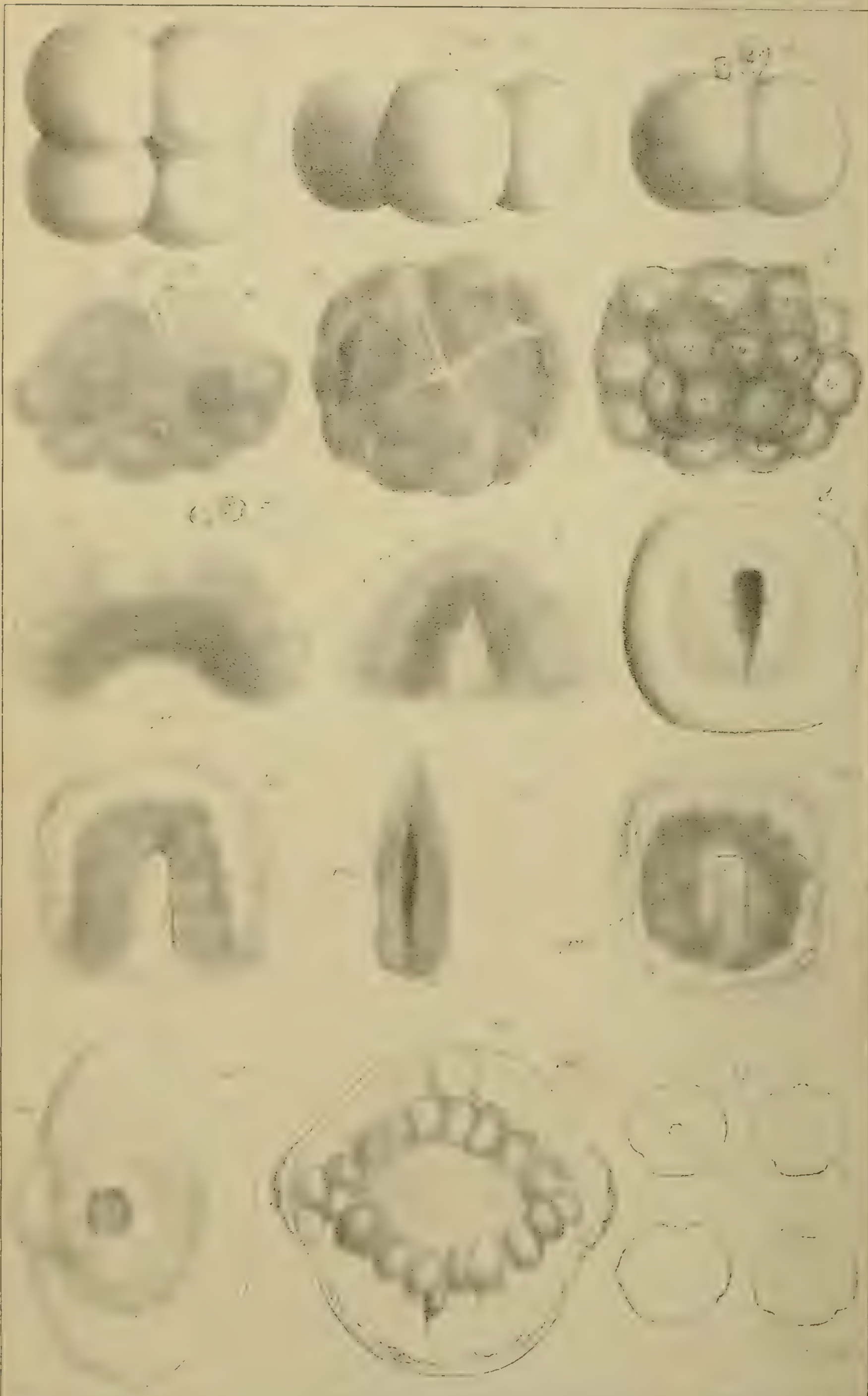
(6) The spiral valve (*a l*).

Fig. 14.—Transparent view of the head of an embryo shortly before the appearance of the external gills. (Magnified 20 diam.) The chief points to be noticed are—

(1) The relation of the cranial nerves to the visceral clefts and the manner in which the glosso-pharyngeal (*g l*) and vagus (*v g*) are united.

(2) The remnants of the pleuro-peritoneal cavity in the head (*p p'*).

(3) The eye (*op*). The stalk, as well as the bulb of the eye, are supposed to be in focus, so that the whole eye has a somewhat peculiar appearance.



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EXPLANATION OF PLATE XVI,

Illustrating Mr. Ray Lankester's Memoir on the Development of the Pond-snail.

Fig. 1.—An egg after the formation of the first cleavage groove. Two Richtungsbläschen (*R.*) are seen. Nat. size of the egg $= \frac{1}{190}$ inch.

Fig. 2.—An egg after division into four cleavage-masses, three of which are seen, and the Richtungsbläschen (*R.*). Nat. size $\frac{1}{180}$ inch (long measurement).

Fig. 3.—The same quadripartite egg seen from below.

Fig. 4.—An egg of a later stage in which smaller cleavage-spheres have made their appearance at one pole. A Richtungsbläschen (*R.*) is seen attached between the four larger cleavage-spheres.

Fig. 5.—The same egg seen from above.

Fig. 6.—The same egg seen from below.

Fig. 7.—A later stage. At the pole *g m* the gastrula-invagination is now commencing. At *R* the Richtungsbläschen, entangled in the discarded vitelline (?) membrane, is seen.

Figs. 8—12.—Various views of the Gastrula of *Lymnæus.* Natural size $= \frac{1}{180}$ inch. The appearance varies according to the position which is assumed. Fig. 9 gives a surface view as seen by reflected light. Fig. 10. The same specimen seen by transmitted light. Fig. 11. Another specimen, two thirds profile view; *g m* is the gastrula-mouth or orifice of invagination.

Fig. 13.—The early phase of the Trochosphere with large lateral lobes (the figure is turned sideways). *m.* Commencing formation of the permanent mouth. Long measurement of this specimen $\frac{1}{130}$ inch.

Fig. 14.—Trochosphere with ciliated annular ridge and commencing mouth, *m.* The large cells of the Gastrula-endoderm are seen to be in connection with the body wall by means of delicate processes. Longest measurement of this specimen $= \frac{1}{140}$ inch.

Fig. 15.—*a, b, c, d.* Successive outlines presented by such a trochosphere as that in the preceding figure during rotation in the antero-posterior direction. The small prominence seen in *b*, and also in fig. 13, in a similar position, is probably the first indication of the foot.

EXPLANATION OF PLATE XVII,

Illustrating Mr. Ray Lankester's Memoir on the Development of the Pond-snail.

Fig. 1.—An embryo between the Trochosphere and Veliger phases—somewhat compressed; longest diameter about $\frac{1}{120}$ inch. *m.* Mouth. *v.* Velum. *f.* Foot. *g e.* Gastrula-endoderm, now assuming a bilobed character—the sac enclosed by it having therefore a double cavity, a right and a left. *g.* Point of closure of the gastrula-mouth. *p i.* Pedicle of invagination—the future rectum. *s p.* The shell-patch—a thickened area of the body wall, on the surface of which the shell first forms, and by invagination of which the shell-gland is produced.

Fig. 2.—Young Veliger, surface view, showing—*m.* Mouth. *v.* Velum. *f.* Foot. Longest diameter about $\frac{1}{100}$ inch.

Fig. 3.—A similar specimen from the oral aspect.

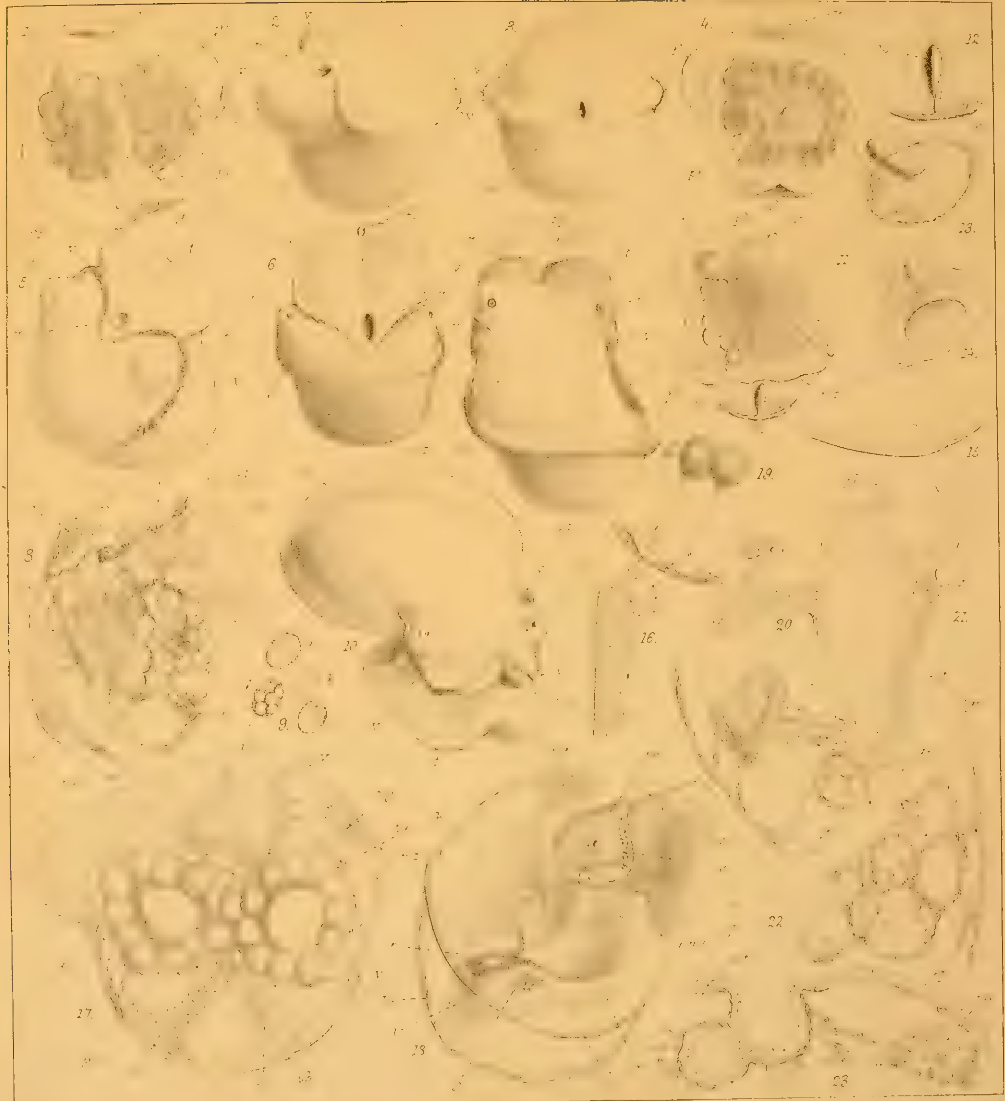
Fig. 4.—A similar specimen somewhat compressed and seen in incomplete optical section. *m.* Mouth. *f.* Foot. *p i.* Pedicle of invagination. *s h.* Shell overlying the depression of the shell-gland, which is now visible.

Fig. 5.—Surface view of a more advanced Veliger, longest diameter about $\frac{1}{90}$ of an inch. *f.* The foot, showing bilobation. *v.* Velum now forming a heart-shaped area, with *m,* the mouth, at its base. *t.* The eye-tentacles.

Fig. 6.—Surface view of a more advanced embryo, in a position frequently assumed at this period of development. Length of the specimen, about $\frac{1}{70}$ inch. *f p.* A doubtful structure, lying between the two lobes of the foot, possibly a foot-pore. Other letters as above.

Fig. 7.—A much more advanced embryo, about $\frac{1}{40}$ of an inch long. *f.* Foot. *f p.* Foot-pore. *v.* Velum now assuming the character of "sub-tentacular lobes." *t.* Tentacles. *l.* Lung-chamber. *m f.* Mantle-flap, or free border of the mantle. *sh.* Shell.

Fig. 8.—An embryo, a little older than that of fig. 5. Length about $\frac{1}{80}$ of an inch, compressed, treated with osmic acid, and seen in partial optical section. *m.* Mouth. *ph.* Pharynx. *ods.* Odontophore-sac. *f.* Foot. *p i.* Pedicle of invagination (rectum) with cæcal termination. *m f.* Mantle-



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flap. *mu.* Muscular-cells passing from body wall to centrally placed gastrula-endoderm. *sh.* Shell-rising up as a watch-glass. *n g.* Nerve-ganglion. *t.* Tentacle. *v.* Velum.

FIG. 9.—*a, b, c. d.*—Four conditions of cells of the gastrula-endoderm from embryos a little younger than that of Fig. 8.

Fig. 10.—A similar embryo to that of fig. 7. Letters as before.

FIG. 11.—A small embryo (about $\frac{1}{95}$ inch long) from a mass containing embryos similar to those of figs. 7 and 10. It is irregularly developed and has the shell-gland occupied by a bright highly-refracting plug, *is.* *f.* Foot. *ph.* Pharynx. *v.* Velum. *m f.* Mantle-flap. *sh.* Shell. *is.* Plug of the shell-gland. *p i.* Pedicle of invagination (rectum).

FIG. 12.—Shell-gland with plug *is,* and external shell *es,* of the same embryo.

Fig. 13.—Shell-gland of another embryo and circular shell-area covered by the disc-like shell.

FIG. 14.—Shell-gland and widely open mouth of the same from another embryo.

FIG. 15.—Optical section of the central portion of the shell-secreting area at a later stage (viz. that of fig. 8), showing the last vestige of the shell-gland as a small depression.

FIG. 16.—Optical section of shell-secreting area of an embryo, similar to that of fig. 17, showing the superficial columnar and deeper fusiform cells, and the delicate shell, *sh.*

FIG. 17.—An embryo younger than that of fig. 5, considerably younger than that of fig. 8, compressed and treated with osmic acid. Long diameter, as thus seen, about $\frac{1}{90}$ inch. *f.* Foot. *ph.* Pharynx. *v.* Velum. *ng.* Nerve-ganglion. *t g e.* Tunic of fusiform cells covering in the gastrula. endoderm. *sh.* Shell. *s s.* Shell gland. *p i.* Pedicle of invagination. *g s.* Right-hand cavity of the bilobed gastrula-stomach. Observe the fusiform cells passing from the body-wall to be connected with this.

FIG. 18.—An embryo of nearly the same age and size as that of fig. 10, treated with osmic acid. *v.* Velum. *f.* Bilobed foot. *ph.* Pharynx. *n g.* Nerve-ganglion. *h.* Heart. *m f.* Mantle flap. *n.* Kidney formed as an in-pushing from the reflected flap of the mantle. *m.* Muscular fibres attached to the bend of the intestine. *i.* Intestine. *g.* Problematical mass of cells lying close to the kidney. *l.* Lung-chamber. *c r.* Cæcal termination of the intestine. *r m.* Retractor (?) muscle.

FIG. 19.—Cells of the body-wall and gastrula-endoderm connected by processes of the latter, from an embryo of the same age as that of fig. 4.

FIG. 20.—Recurved and cæcal termination of the rectum developed from

the pedicle of invagination, from an embryo a little older than that of fig. 17.

Fig. 21.—Alimentary canal of an embryo about the age of that of fig. 8. *ph.* Pharynx. *a.* Œsophagus not yet open to pharynx. *st.* Stomach; its structure concealed and obscured by the adjacent gastrula-endoderm cell-masses. *i.* Intestine. *c.* Its cæcal termination. *g e.* Two of the gastrula-endoderm cells, now assuming the character of pellucid globules with superficial granular networks. *m.* Branched muscular cell passing from the body-wall to the latter. The intestine is seen to have a superficial tunic of fusiform cells, and to be connected by such cells to the body-wall.

Fig. 22.—Body-wall and some of the modified gastrula-endoderm cells, from a stage between those of fig. 17 and fig. 8. *ep.* Epiblast. *t g e.* Tunic of fusiform cells covering the pellucid bodies and their granular networks.

Fig. 23.—Anterior part of the alimentary canal and body-wall, of same age as fig. 21. *ep.* Epiblast. *m t.* Muscular tunic. *m.* Muscles. *n g.* nerve-ganglion.